FIG. 1

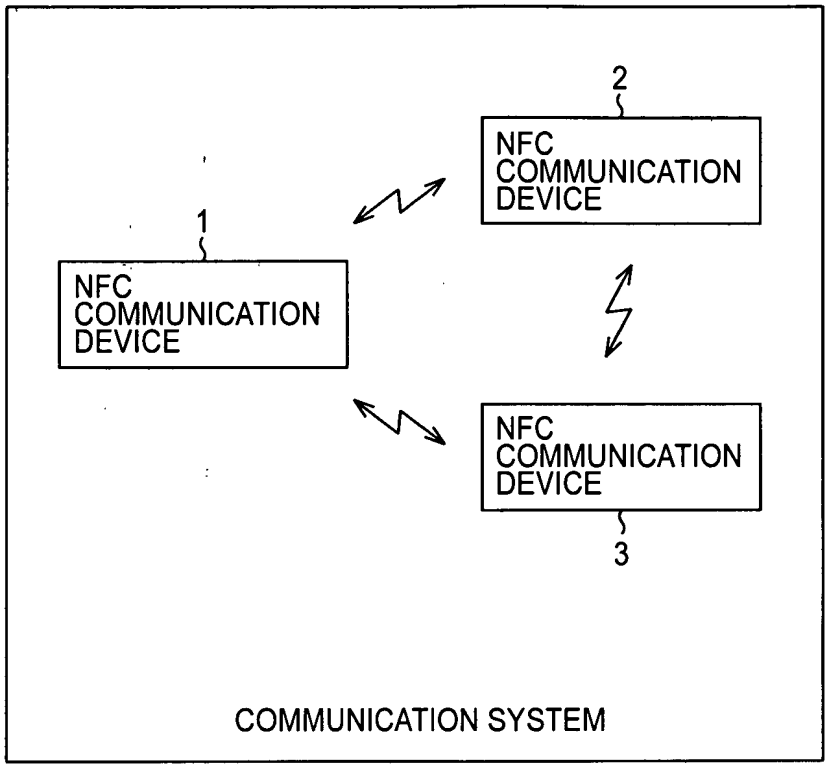

2
NFC COMMUNICATION DEVICE
1
NFC COMMUNICATION DEVICE
NFC COMMUNICATION DEVICE
3
COMMUNICATION SYSTEM

FIG. 2

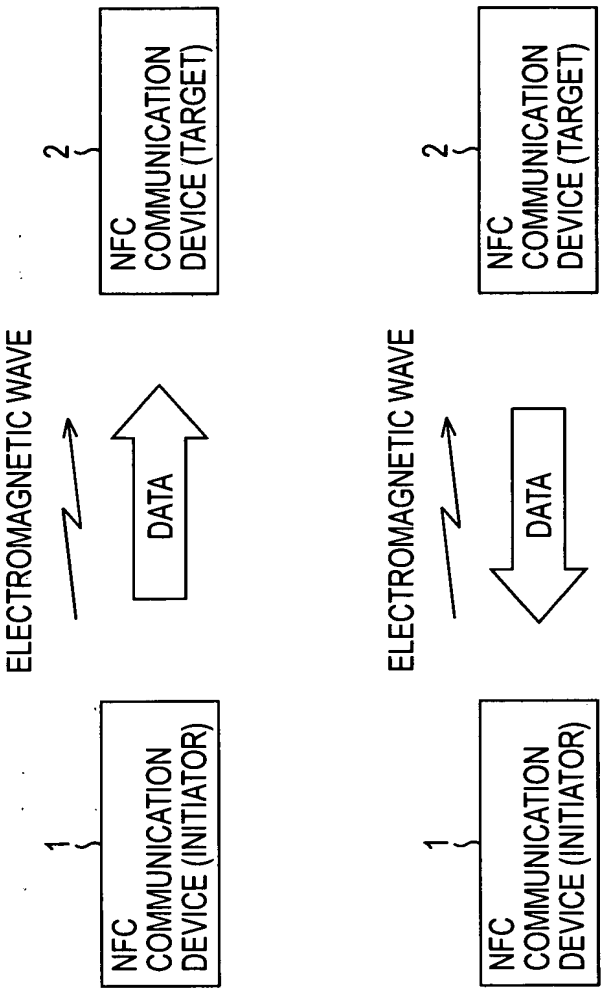

NFC COMMUNICATION DEVICE (INITIATOR)
1
ELECTROMAGNETIC WAVE
DATA
NFC COMMUNICATION DEVICE (TARGET)
2
NFC COMMUNICATION DEVICE (INITIATOR)
1
ELECTROMAGNETIC WAVE
DATA
NFC COMMUNICATION DEVICE (TARGET)
2

FIG. 3

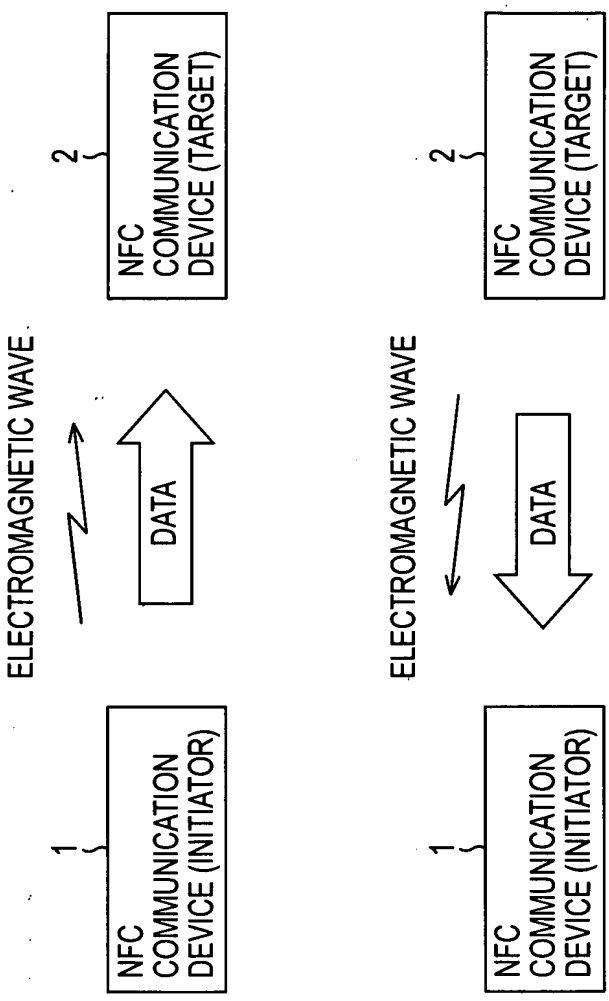

NFC COMMUNICATION DEVICE (INITIATOR)
1
ELECTROMAGNETIC WAVE
DATA
NFC COMMUNICATION DEVICE (TARGET)
2
NFC COMMUNICATION DEVICE (INITIATOR)
1
ELECTROMAGNETIC WAVE
DATA
NFC COMMUNICATION DEVICE (TARGET)
2

FIG. 4

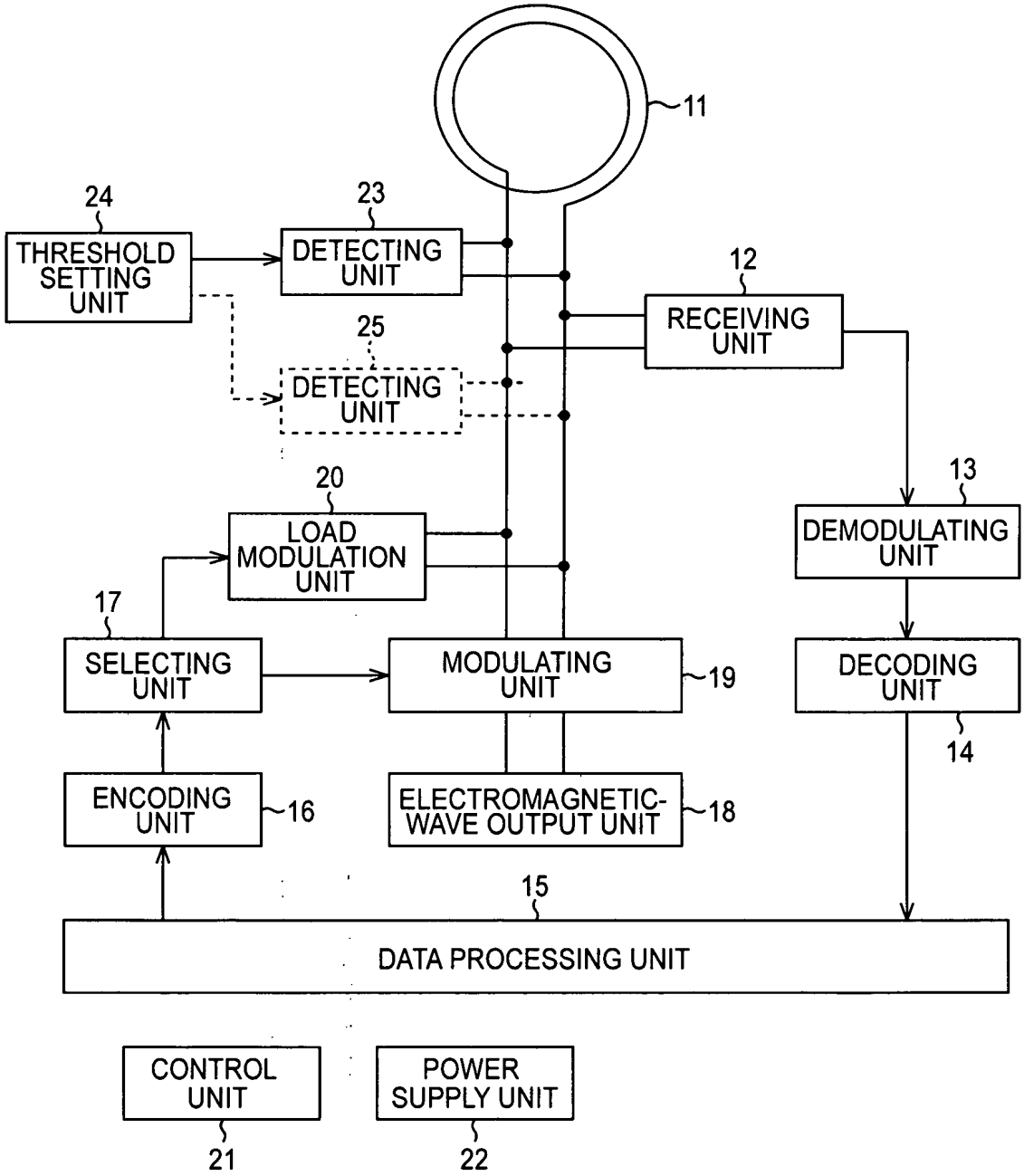

11
24
THRESHOLD SETTING UNIT
23
DETECTING UNIT
12
RECEIVING UNIT
25
DETECTING UNIT
20
LOAD MODULATION UNIT
13
DEMODULATING UNIT
17
SELECTING UNIT
MODULATING UNIT
19
DECODING UNIT
14
ENCODING UNIT
16
ELECTROMAGNETIC-WAVE OUTPUT UNIT
18
15
DATA PROCESSING UNIT
CONTROL UNIT
21
POWER SUPPLY UNIT
22

FIG. 5

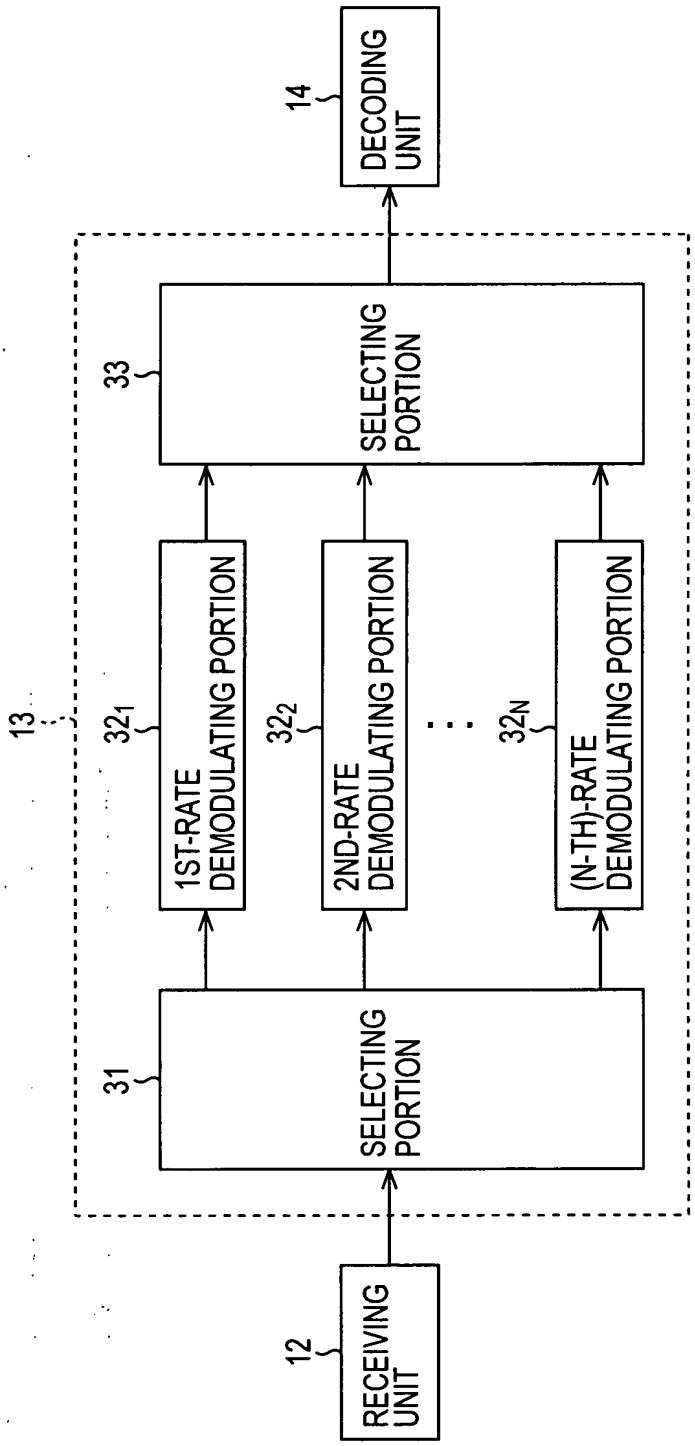

14
DECODING UNIT
33
SELECTING PORTION
13
32₁
1ST-RATE DEMODULATING PORTION
32₂
2ND-RATE DEMODULATING PORTION
32N
(N-TH)-RATE DEMODULATING PORTION
31
SELECTING PORTION
12
RECEIVING UNIT

FIG. 6

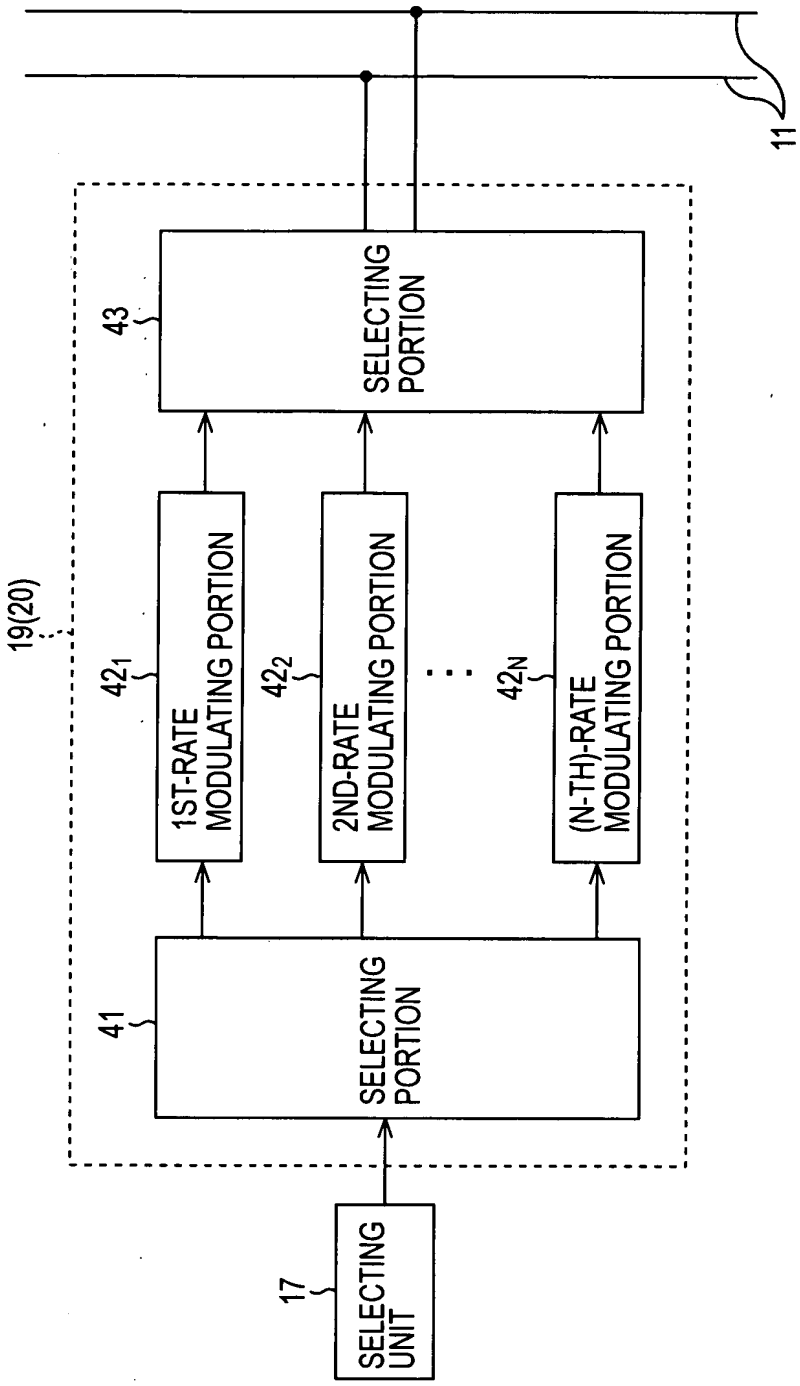

11
19(20)
43
SELECTING PORTION
42₁
1ST-RATE MODULATING PORTION
42₂
2ND-RATE MODULATING PORTION
42N
(N-TH)-RATE MODULATING PORTION
41
SELECTING PORTION
17
SELECTING UNIT

FIG. 7

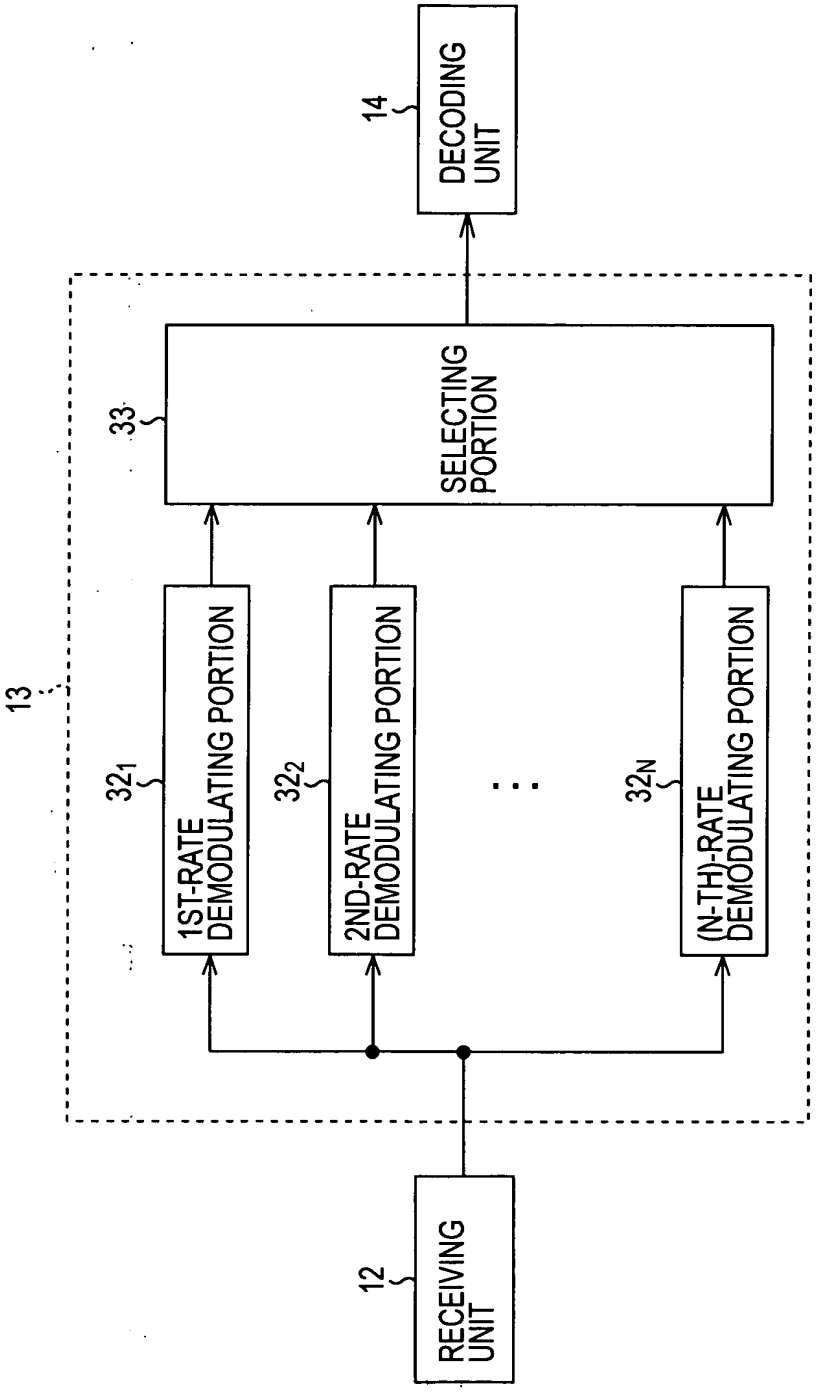

14
DECODING UNIT
33
SELECTING PORTION
13
32₁
1ST-RATE DEMODULATING PORTION
32₂
2ND-RATE DEMODULATING PORTION
...
32N
(N-TH)-RATE DEMODULATING PORTION
12
RECEIVING UNIT

FIG. 8

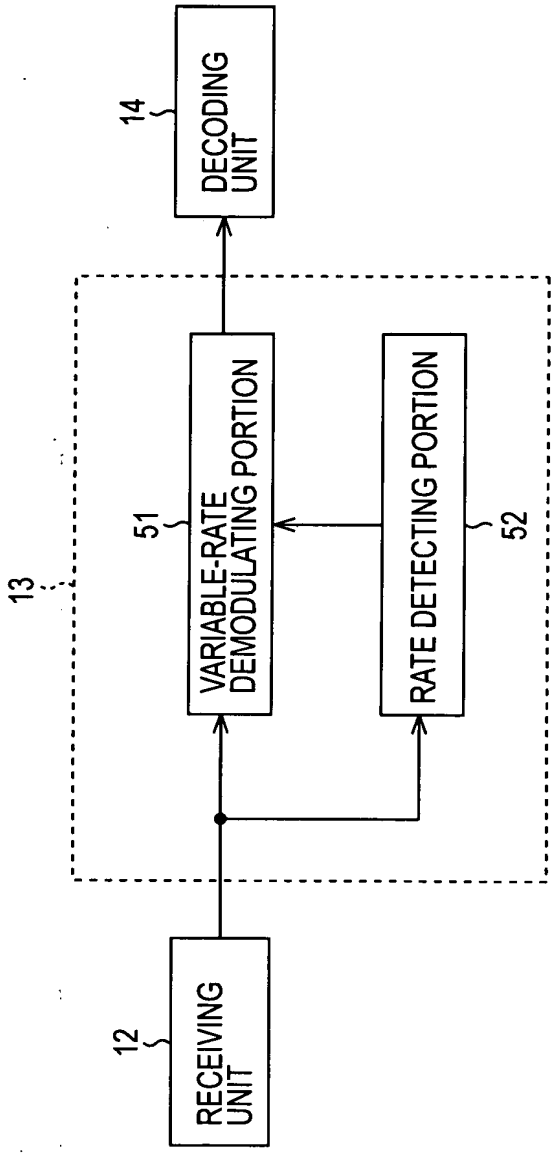

14
DECODING UNIT
13
51
VARIABLE-RATE DEMODULATING PORTION
RATE DETECTING PORTION
52
12
RECEIVING UNIT

FIG. 9

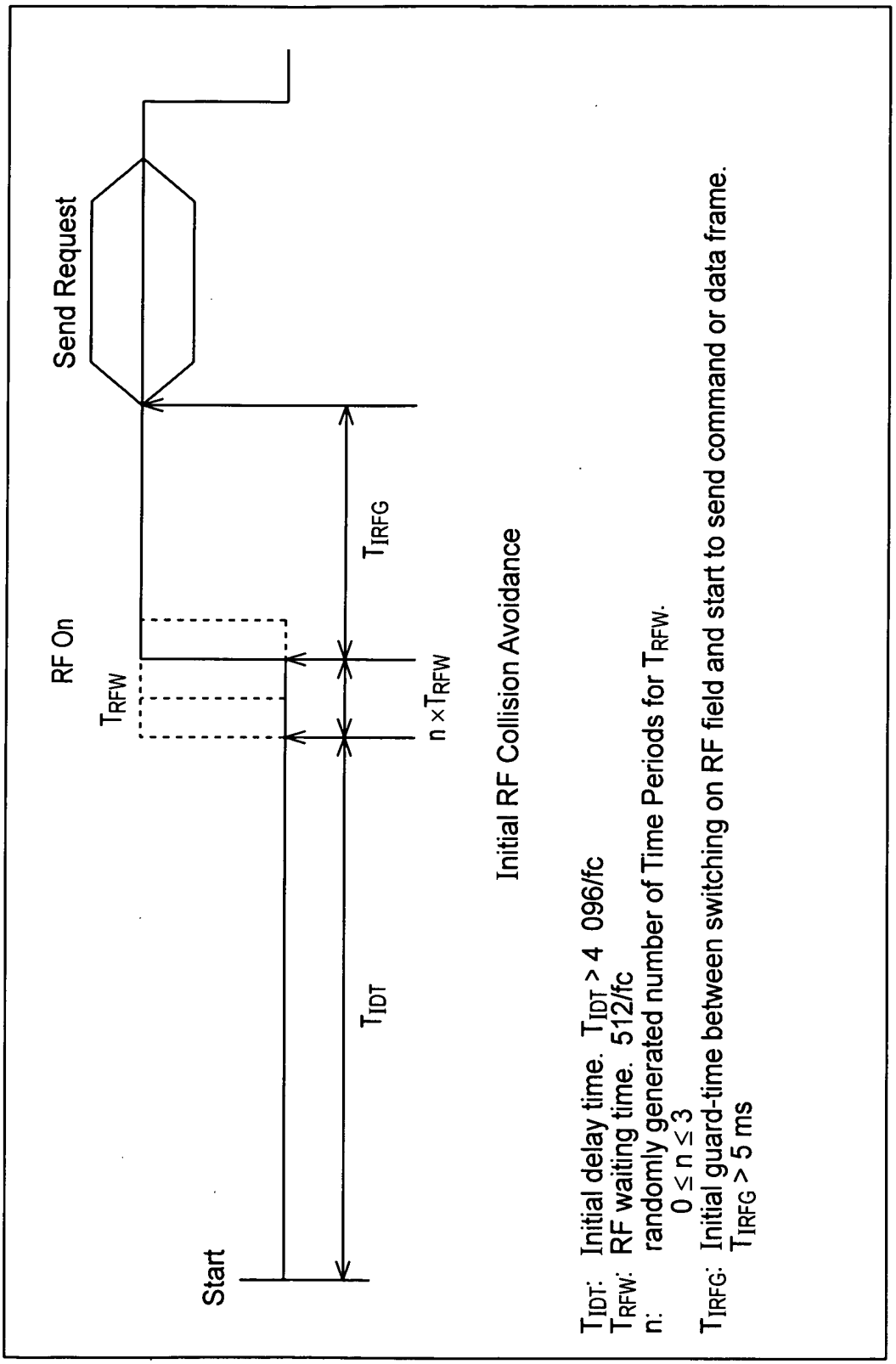

Send Request
RF On
T_{RFW}
T_{IRFG}
$n \times T_{RFW}$
T_{IDT}
Start
Initial RF Collision Avoidance
T_{IDT}: Initial delay time. $T_{IDT} > 4\ 096/fc$
T_{RFW}: RF waiting time. 512/fc
n: randomly generated number of Time Periods for T_{RFW}.
$0 \leq n \leq 3$
T_{IRFG}: Initial guard-time between switching on RF field and start to send command or data frame.
$T_{IRFG} > 5$ ms

FIG. 10

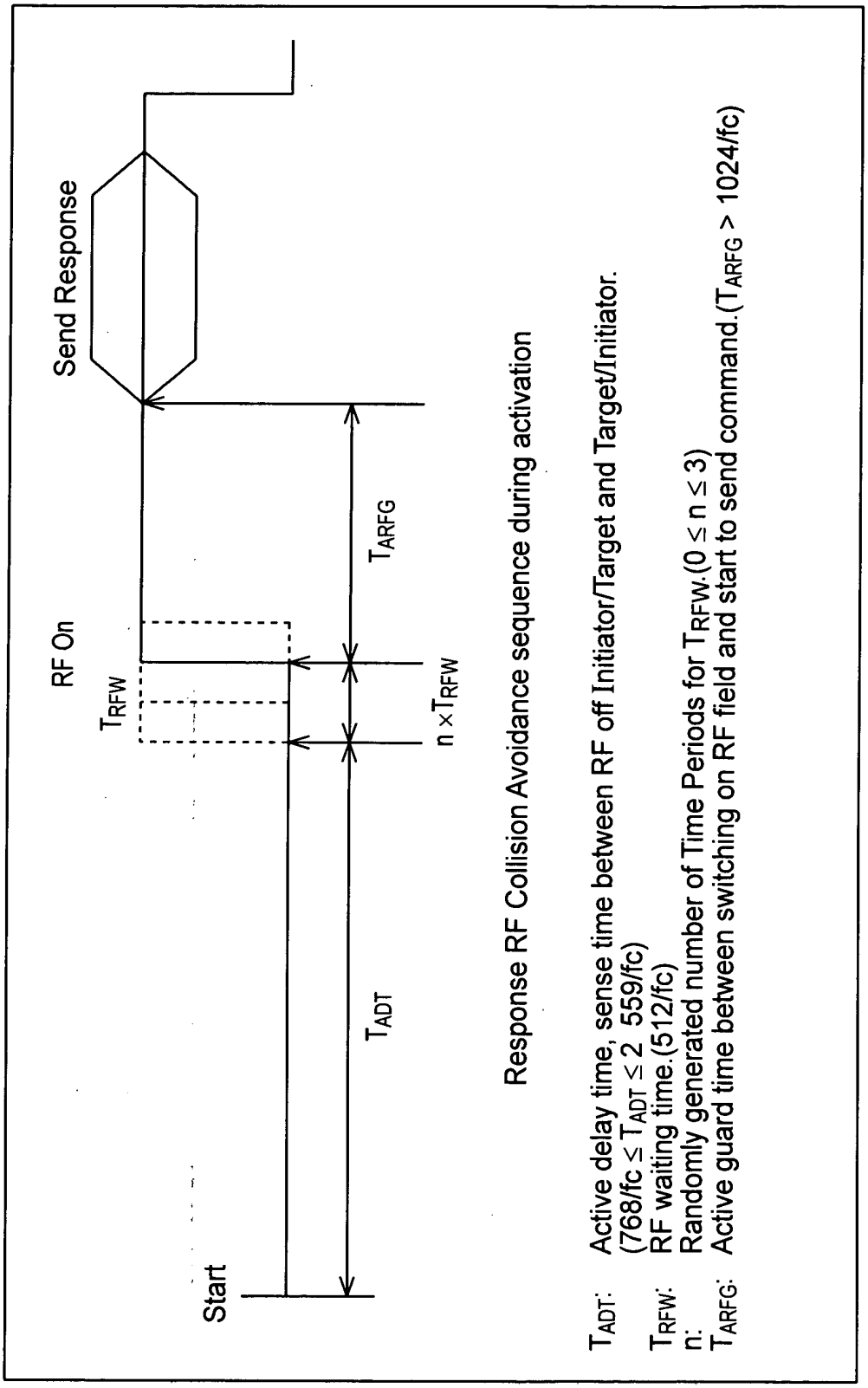

Send Response
RF On
T_{RFW}
T_{ARFG}
$n \times T_{RFW}$
T_{ADT}
Start
Response RF Collision Avoidance sequence during activation
T_{ADT}: Active delay time, sense time between RF off Initiator/Target and Target/Initiator. (768/fc ≤ T_{ADT} ≤ 2 559/fc)
T_{RFW}: RF waiting time.(512/fc)
n: Randomly generated number of Time Periods for T_{RFW}.(0 ≤ n ≤ 3)
T_{ARFG}: Active guard time between switching on RF field and start to send command.(T_{ARFG} > 1024/fc)

FIG. 11

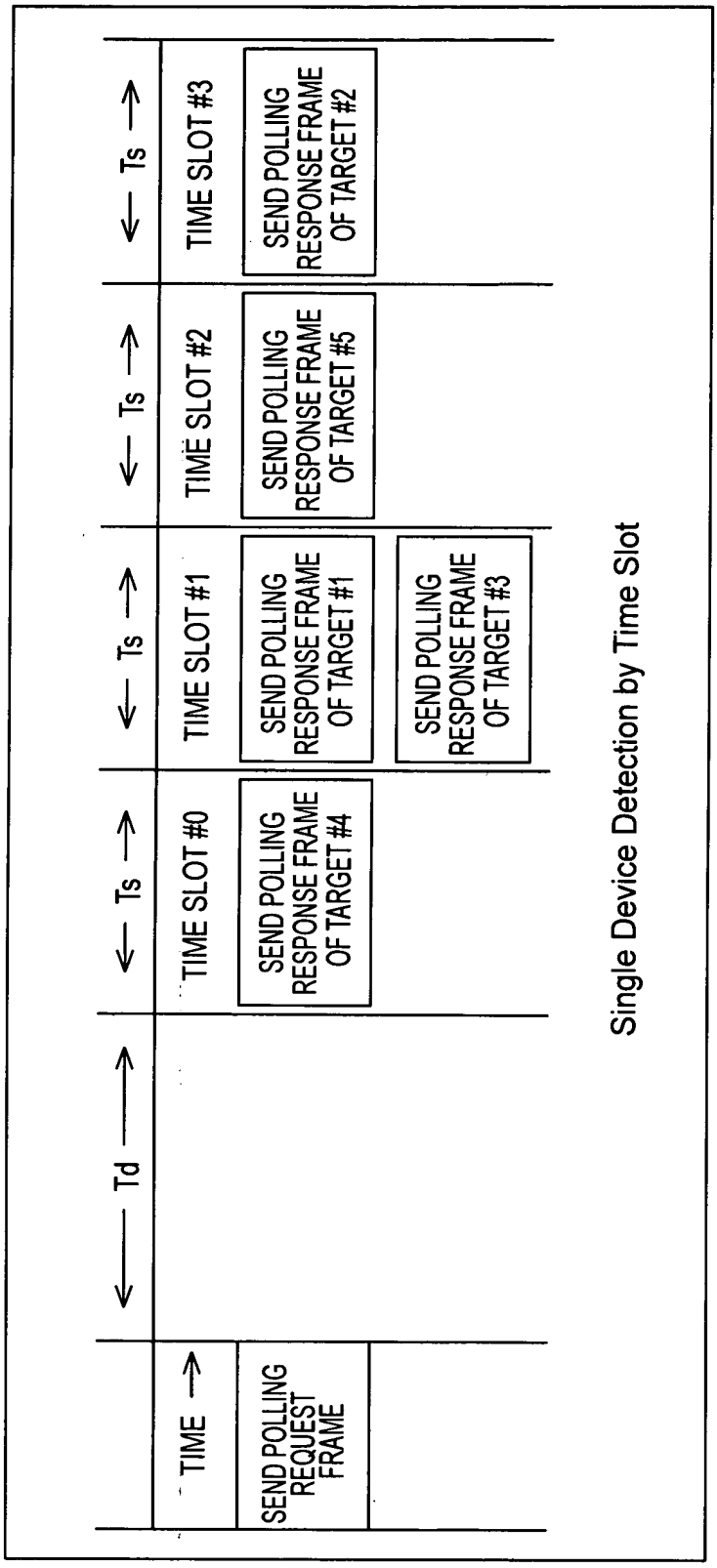

TIME
SEND POLLING REQUEST FRAME
Td
Ts
TIME SLOT #0
SEND POLLING RESPONSE FRAME OF TARGET #4
Ts
TIME SLOT #1
SEND POLLING RESPONSE FRAME OF TARGET #1
SEND POLLING RESPONSE FRAME OF TARGET #3
Ts
TIME SLOT #2
SEND POLLING RESPONSE FRAME OF TARGET #5
Ts
TIME SLOT #3
SEND POLLING RESPONSE FRAME OF TARGET #2
Single Device Detection by Time Slot

FIG. 12

COMMAND/RESPONSE
ATR_REQ
ATR_RES
WUP_REQ
WUP_RES
PSL_REQ
PSL_RES
DEP_REQ
DEP_RES
DSL_REQ
DSL_RES
RLS_REQ
RLS_RES

FIG. 13

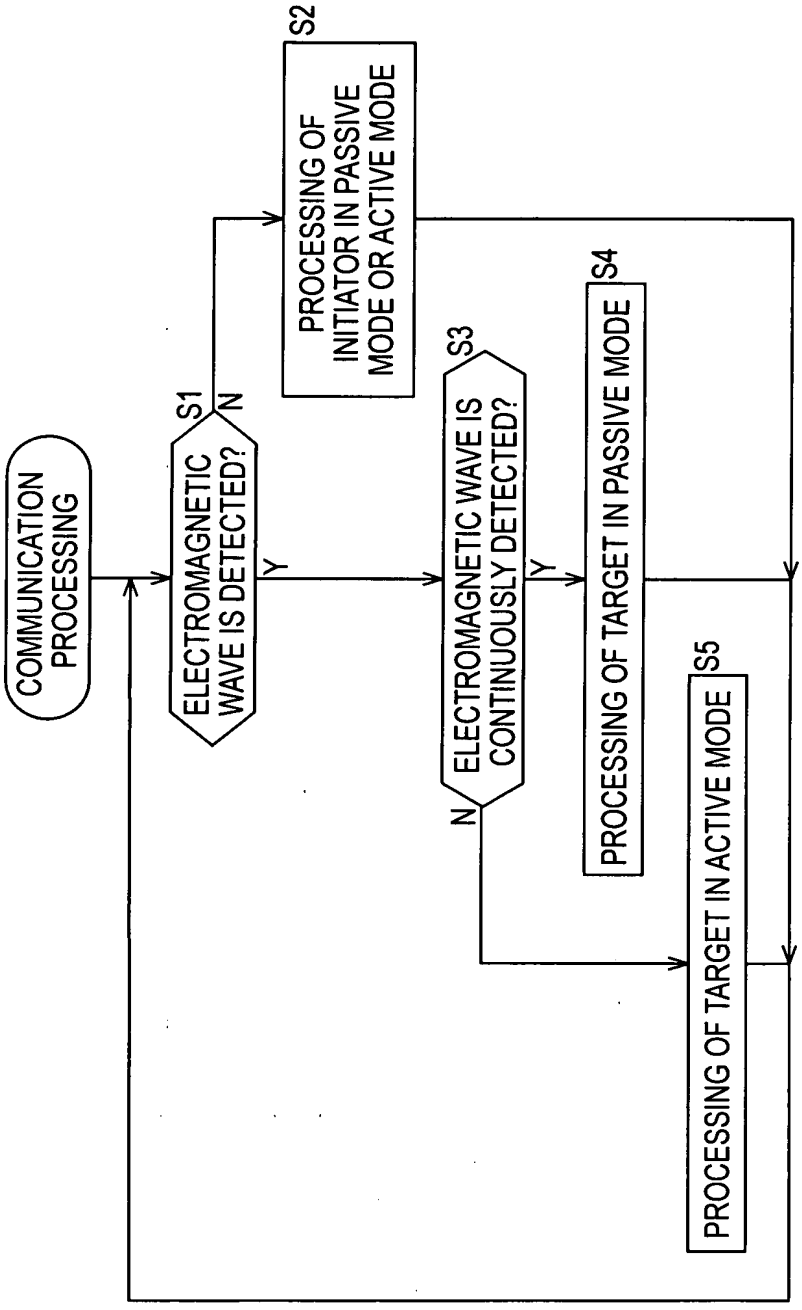

COMMUNICATION PROCESSING
S1
ELECTROMAGNETIC WAVE IS DETECTED?
N
Y
S2
PROCESSING OF INITIATOR IN PASSIVE MODE OR ACTIVE MODE
S3
ELECTROMAGNETIC WAVE IS CONTINUOUSLY DETECTED?
N
Y
S4
PROCESSING OF TARGET IN PASSIVE MODE
S5
PROCESSING OF TARGET IN ACTIVE MODE

FIG. 14

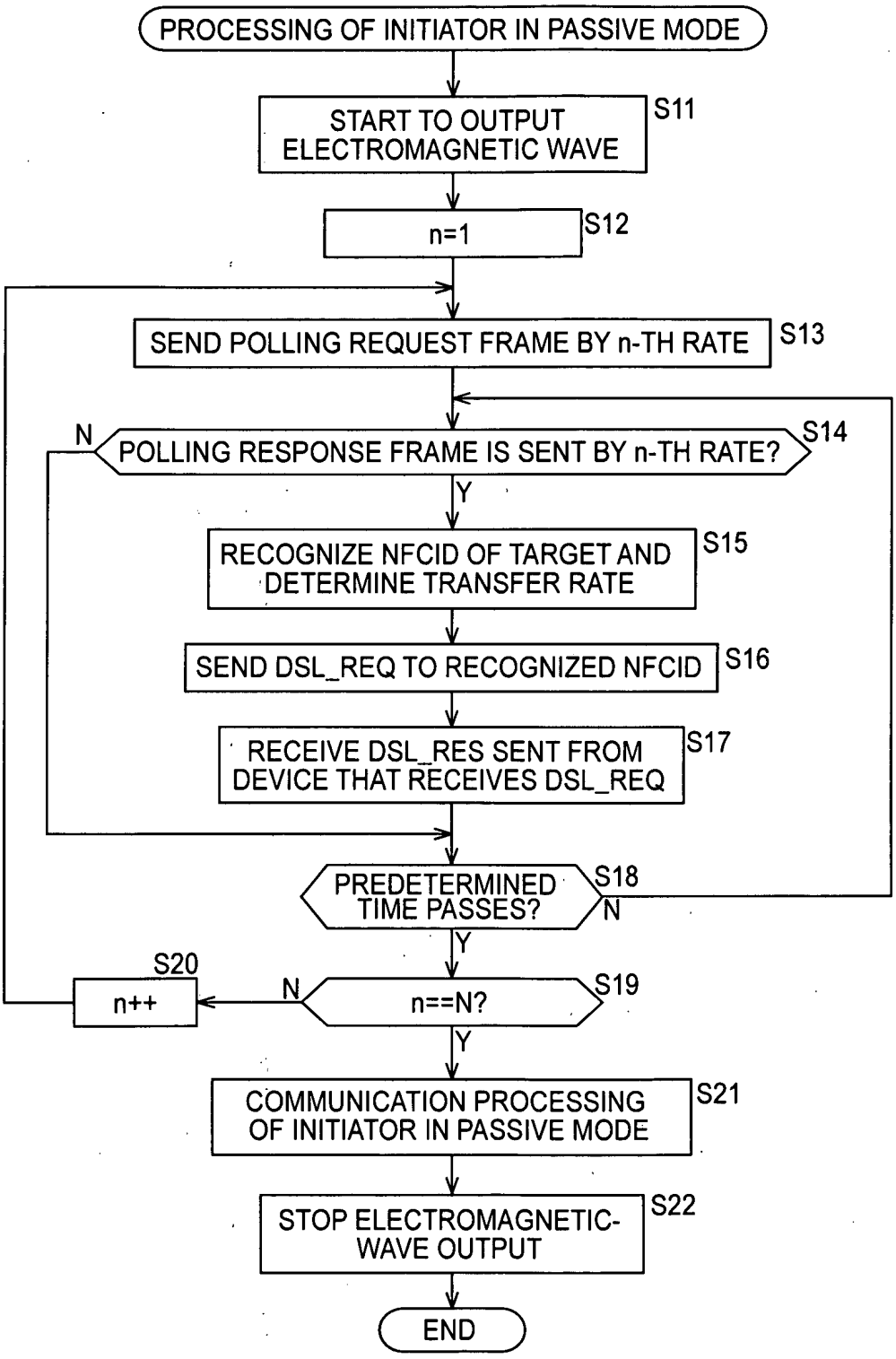

PROCESSING OF INITIATOR IN PASSIVE MODE
START TO OUTPUT ELECTROMAGNETIC WAVE
S11
n=1
S12
SEND POLLING REQUEST FRAME BY n-TH RATE
S13
N
POLLING RESPONSE FRAME IS SENT BY n-TH RATE?
S14
Y
RECOGNIZE NFCID OF TARGET AND DETERMINE TRANSFER RATE
S15
SEND DSL_REQ TO RECOGNIZED NFCID
S16
RECEIVE DSL_RES SENT FROM DEVICE THAT RECEIVES DSL_REQ
S17
PREDETERMINED TIME PASSES?
S18
N
Y
S20
n++
N
n==N?
S19
Y
COMMUNICATION PROCESSING OF INITIATOR IN PASSIVE MODE
S21
STOP ELECTROMAGNETIC-WAVE OUTPUT
S22
END

FIG. 15

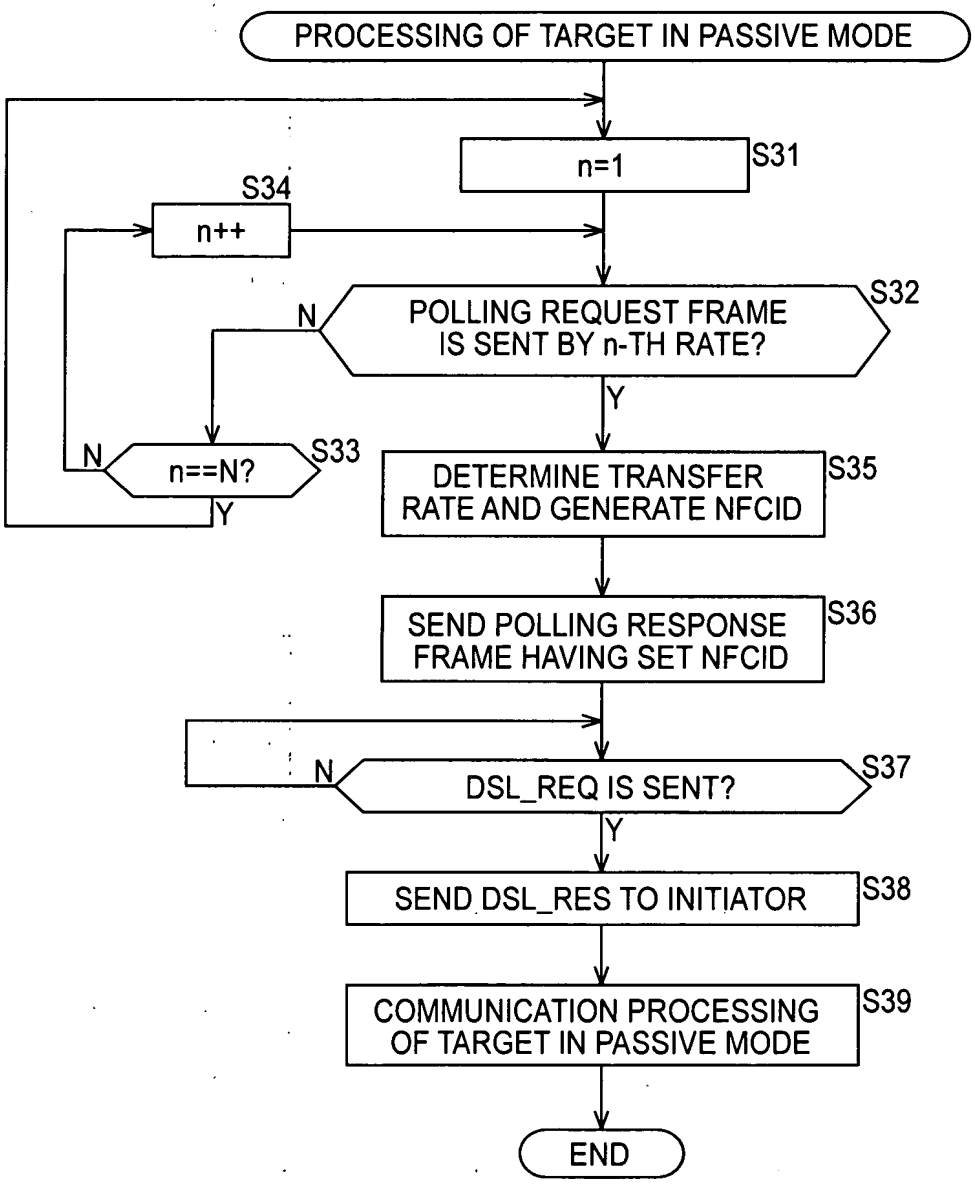

PROCESSING OF TARGET IN PASSIVE MODE
n=1
S31
S34
n++
N
POLLING REQUEST FRAME IS SENT BY n-TH RATE?
S32
Y
N
n==N?
S33
Y
DETERMINE TRANSFER RATE AND GENERATE NFCID
S35
SEND POLLING RESPONSE FRAME HAVING SET NFCID
S36
N
DSL_REQ IS SENT?
S37
Y
SEND DSL_RES TO INITIATOR
S38
COMMUNICATION PROCESSING OF TARGET IN PASSIVE MODE
S39
END

FIG. 16

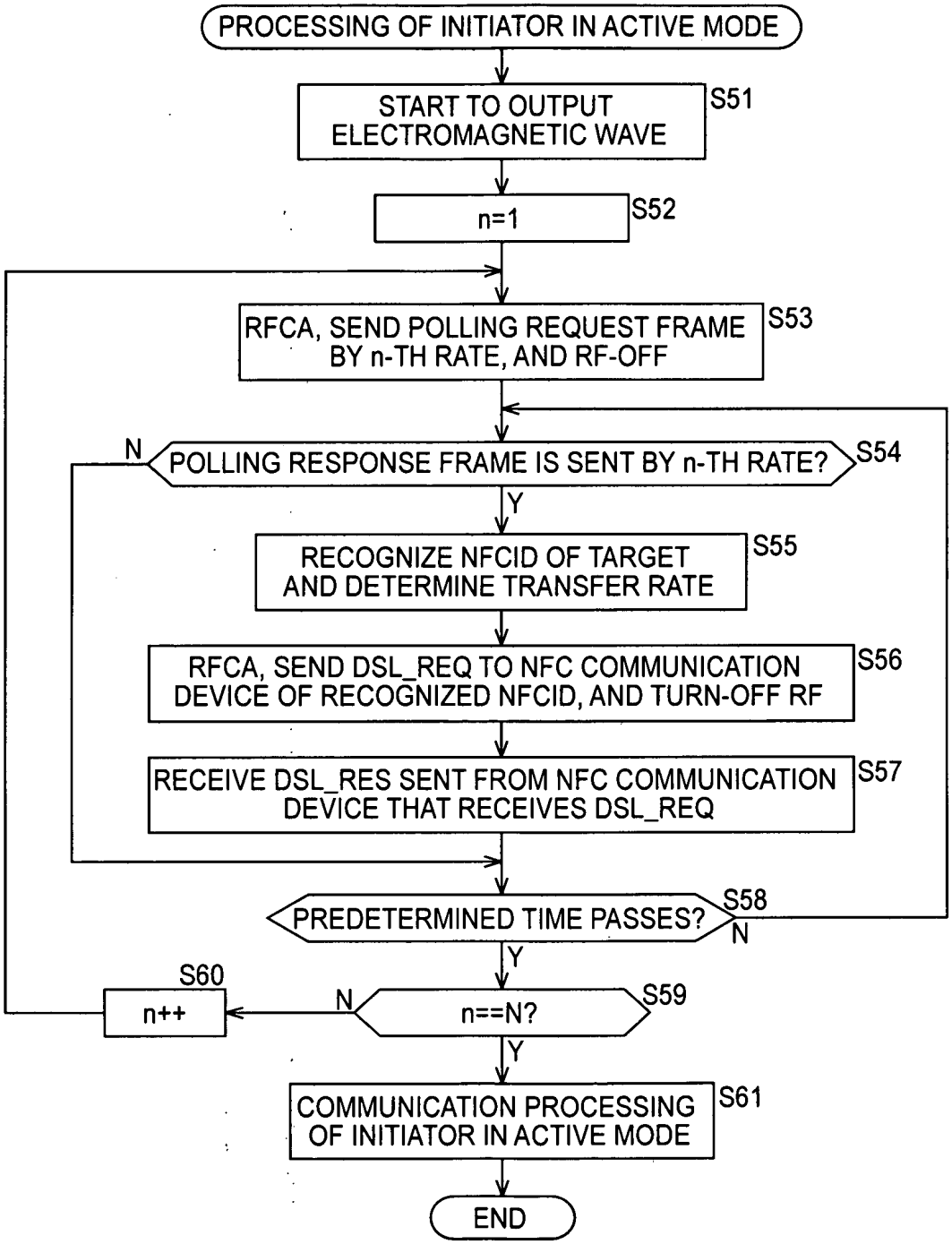

PROCESSING OF INITIATOR IN ACTIVE MODE
START TO OUTPUT ELECTROMAGNETIC WAVE
S51
n=1
S52
RFCA, SEND POLLING REQUEST FRAME BY n-TH RATE, AND RF-OFF
S53
N
POLLING RESPONSE FRAME IS SENT BY n-TH RATE?
S54
Y
RECOGNIZE NFCID OF TARGET AND DETERMINE TRANSFER RATE
S55
RFCA, SEND DSL_REQ TO NFC COMMUNICATION DEVICE OF RECOGNIZED NFCID, AND TURN-OFF RF
S56
RECEIVE DSL_RES SENT FROM NFC COMMUNICATION DEVICE THAT RECEIVES DSL_REQ
S57
PREDETERMINED TIME PASSES?
S58
N
Y
S60
n++
N
n==N?
S59
Y
COMMUNICATION PROCESSING OF INITIATOR IN ACTIVE MODE
S61
END

FIG. 17

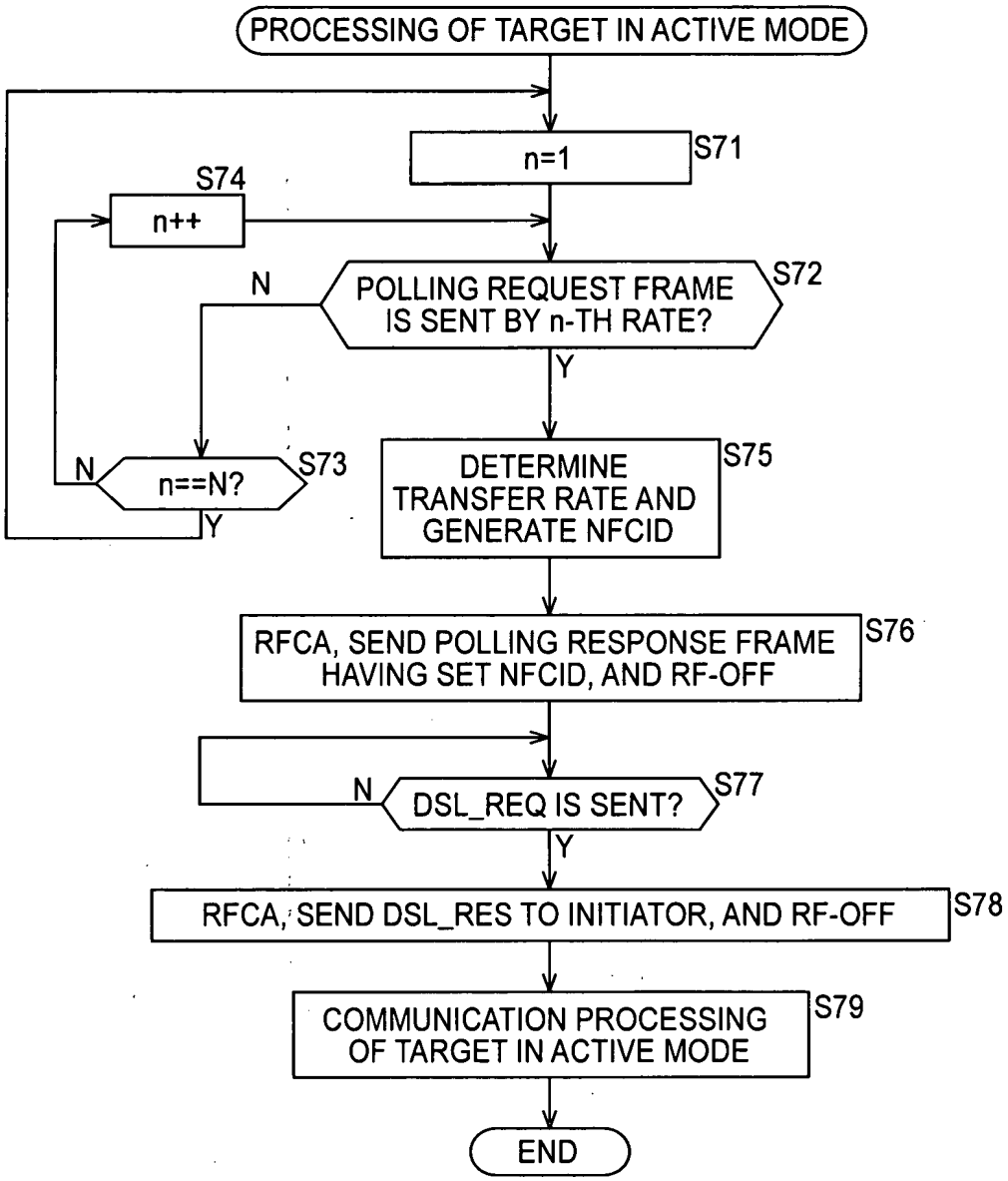

PROCESSING OF TARGET IN ACTIVE MODE
n=1
S71
S74
n++
N
POLLING REQUEST FRAME IS SENT BY n-TH RATE?
S72
Y
N
n==N?
S73
Y
DETERMINE TRANSFER RATE AND GENERATE NFCID
S75
RFCA, SEND POLLING RESPONSE FRAME HAVING SET NFCID, AND RF-OFF
S76
N
DSL_REQ IS SENT?
S77
Y
RFCA, SEND DSL_RES TO INITIATOR, AND RF-OFF
S78
COMMUNICATION PROCESSING OF TARGET IN ACTIVE MODE
S79
END

FIG. 18

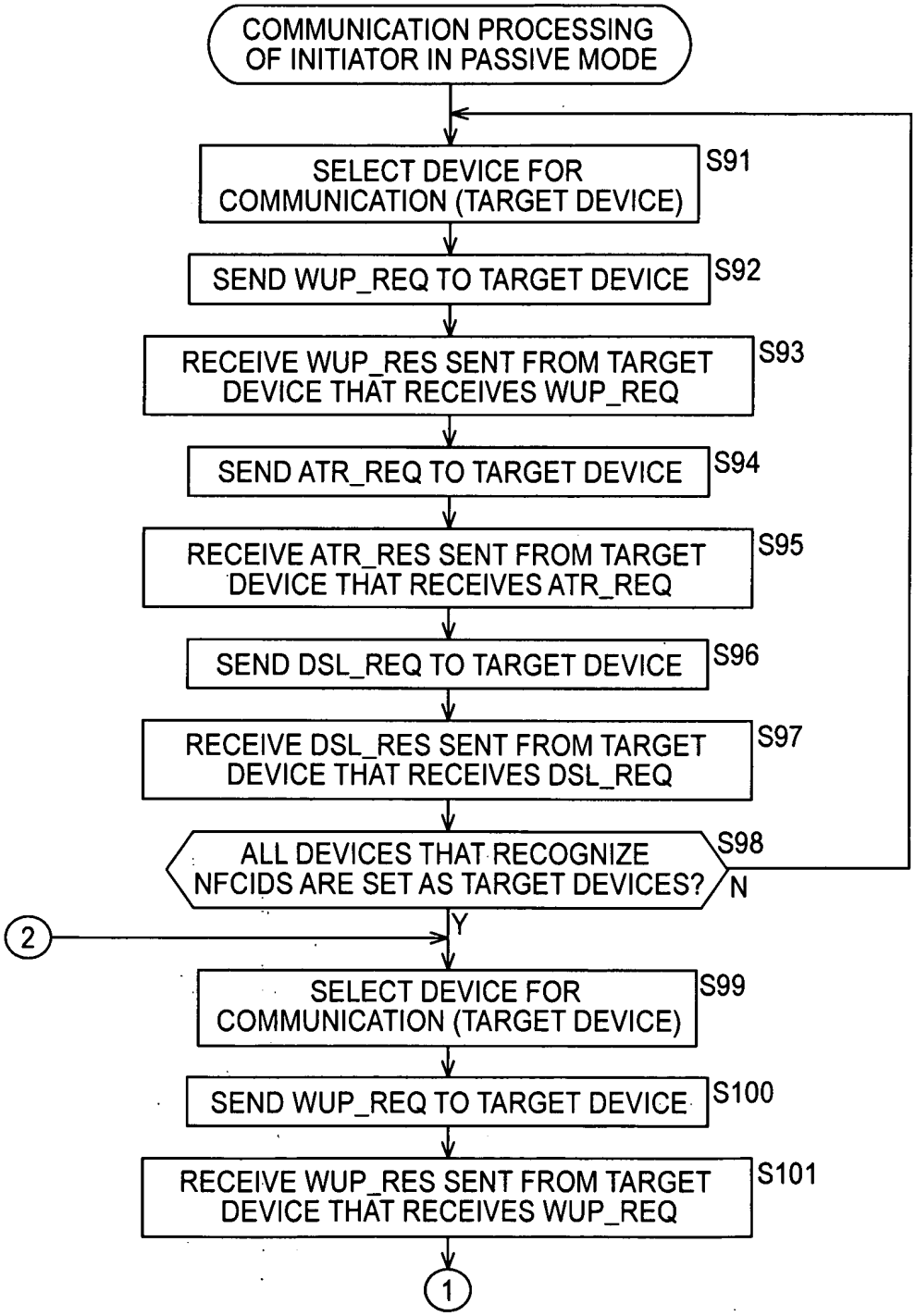

COMMUNICATION PROCESSING OF INITIATOR IN PASSIVE MODE
SELECT DEVICE FOR COMMUNICATION (TARGET DEVICE)
S91
SEND WUP_REQ TO TARGET DEVICE
S92
RECEIVE WUP_RES SENT FROM TARGET DEVICE THAT RECEIVES WUP_REQ
S93
SEND ATR_REQ TO TARGET DEVICE
S94
RECEIVE ATR_RES SENT FROM TARGET DEVICE THAT RECEIVES ATR_REQ
S95
SEND DSL_REQ TO TARGET DEVICE
S96
RECEIVE DSL_RES SENT FROM TARGET DEVICE THAT RECEIVES DSL_REQ
S97
ALL DEVICES THAT RECOGNIZE NFCIDS ARE SET AS TARGET DEVICES?
S98
N
Y
2
SELECT DEVICE FOR COMMUNICATION (TARGET DEVICE)
S99
SEND WUP_REQ TO TARGET DEVICE
S100
RECEIVE WUP_RES SENT FROM TARGET DEVICE THAT RECEIVES WUP_REQ
S101
1

FIG. 19

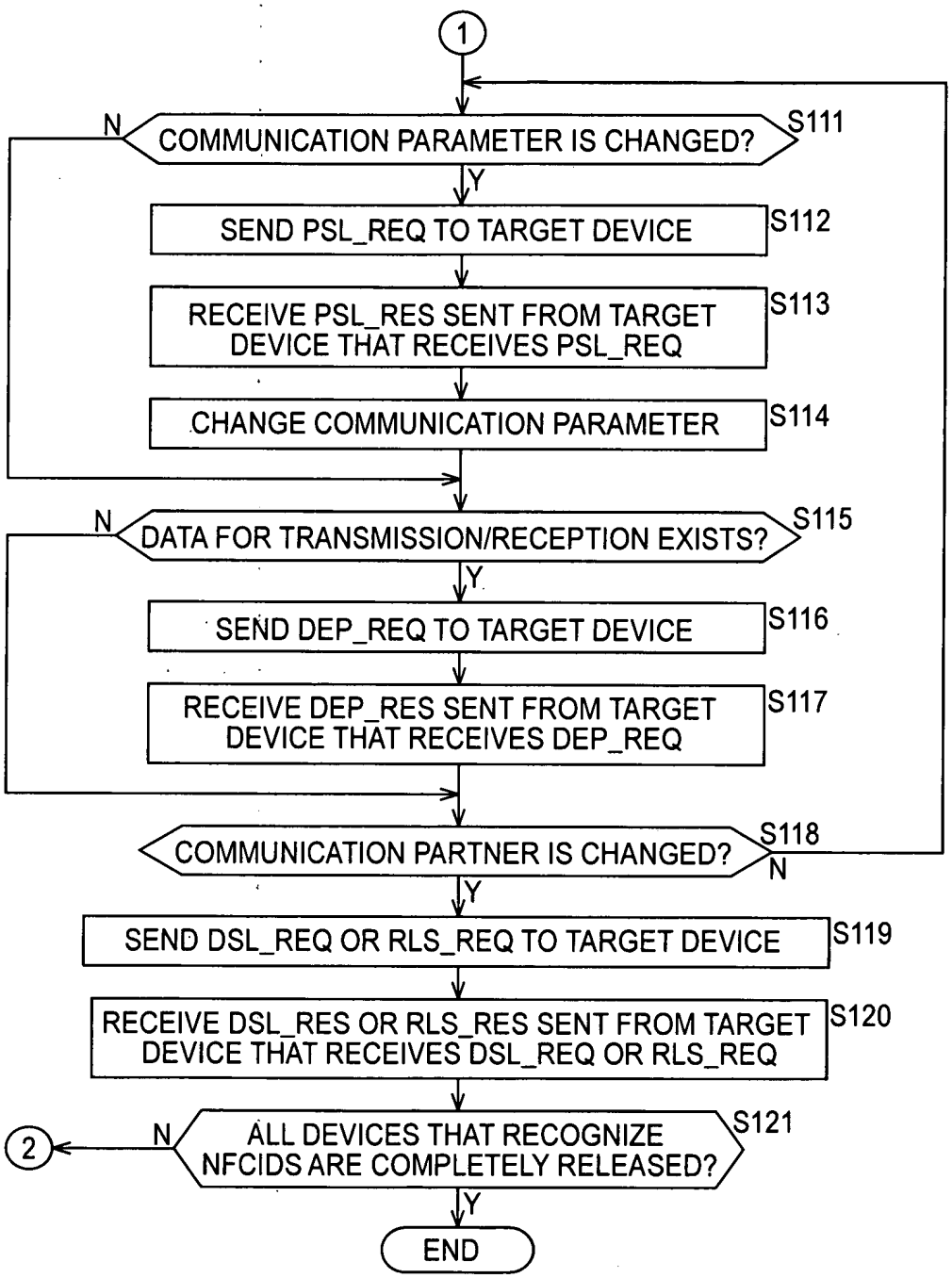

1
COMMUNICATION PARAMETER IS CHANGED?
S111
N
Y
SEND PSL_REQ TO TARGET DEVICE
S112
RECEIVE PSL_RES SENT FROM TARGET DEVICE THAT RECEIVES PSL_REQ
S113
CHANGE COMMUNICATION PARAMETER
S114
DATA FOR TRANSMISSION/RECEPTION EXISTS?
S115
N
Y
SEND DEP_REQ TO TARGET DEVICE
S116
RECEIVE DEP_RES SENT FROM TARGET DEVICE THAT RECEIVES DEP_REQ
S117
COMMUNICATION PARTNER IS CHANGED?
S118
N
Y
SEND DSL_REQ OR RLS_REQ TO TARGET DEVICE
S119
RECEIVE DSL_RES OR RLS_RES SENT FROM TARGET DEVICE THAT RECEIVES DSL_REQ OR RLS_REQ
S120
ALL DEVICES THAT RECOGNIZE NFCIDS ARE COMPLETELY RELEASED?
S121
N
2
Y
END

FIG. 20

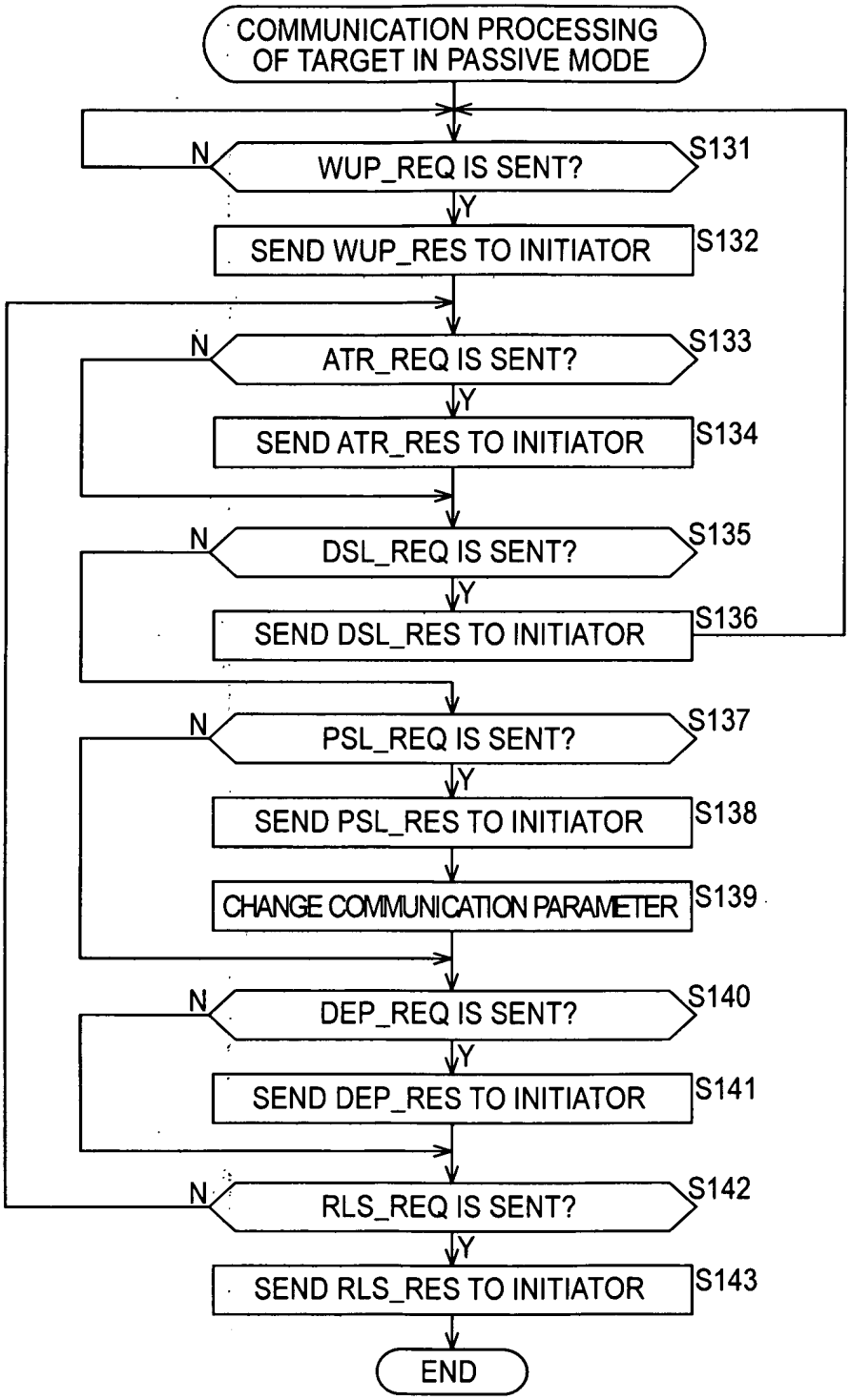

COMMUNICATION PROCESSING OF TARGET IN PASSIVE MODE
WUP_REQ IS SENT?
S131
N
Y
SEND WUP_RES TO INITIATOR
S132
ATR_REQ IS SENT?
S133
SEND ATR_RES TO INITIATOR
S134
DSL_REQ IS SENT?
S135
SEND DSL_RES TO INITIATOR
S136
PSL_REQ IS SENT?
S137
SEND PSL_RES TO INITIATOR
S138
CHANGE COMMUNICATION PARAMETER
S139
DEP_REQ IS SENT?
S140
SEND DEP_RES TO INITIATOR
S141
RLS_REQ IS SENT?
S142
SEND RLS_RES TO INITIATOR
S143
END

FIG. 21

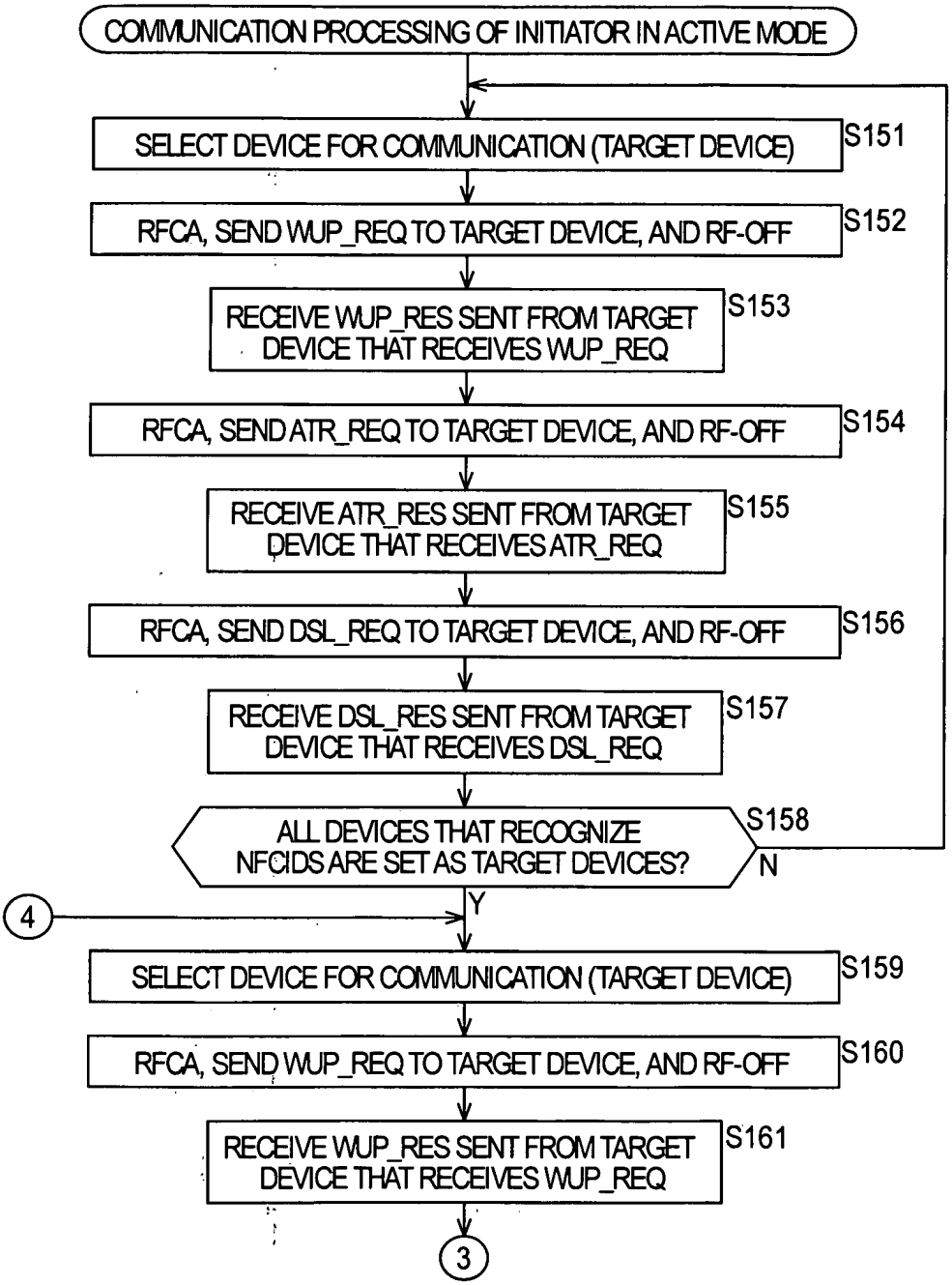

COMMUNICATION PROCESSING OF INITIATOR IN ACTIVE MODE
SELECT DEVICE FOR COMMUNICATION (TARGET DEVICE)
S151
RFCA, SEND WUP_REQ TO TARGET DEVICE, AND RF-OFF
S152
RECEIVE WUP_RES SENT FROM TARGET DEVICE THAT RECEIVES WUP_REQ
S153
RFCA, SEND ATR_REQ TO TARGET DEVICE, AND RF-OFF
S154
RECEIVE ATR_RES SENT FROM TARGET DEVICE THAT RECEIVES ATR_REQ
S155
RFCA, SEND DSL_REQ TO TARGET DEVICE, AND RF-OFF
S156
RECEIVE DSL_RES SENT FROM TARGET DEVICE THAT RECEIVES DSL_REQ
S157
ALL DEVICES THAT RECOGNIZE NFCIDS ARE SET AS TARGET DEVICES?
S158
N
Y
4
SELECT DEVICE FOR COMMUNICATION (TARGET DEVICE)
S159
RFCA, SEND WUP_REQ TO TARGET DEVICE, AND RF-OFF
S160
RECEIVE WUP_RES SENT FROM TARGET DEVICE THAT RECEIVES WUP_REQ
S161
3

FIG. 22

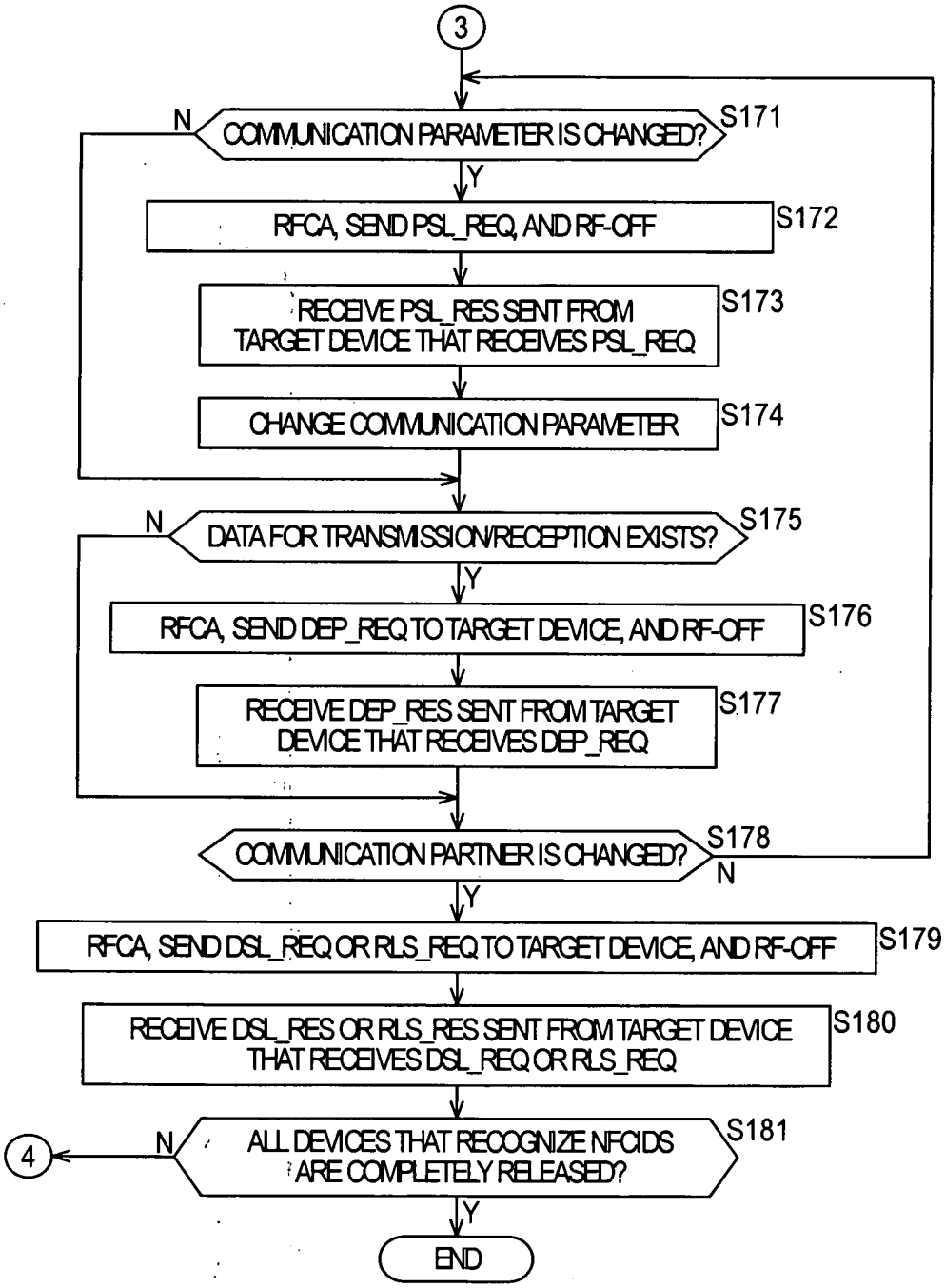

3
N
COMMUNICATION PARAMETER IS CHANGED?
S171
Y
RFCA, SEND PSL_REQ, AND RF-OFF
S172
RECEIVE PSL_RES SENT FROM TARGET DEVICE THAT RECEIVES PSL_REQ
S173
CHANGE COMMUNICATION PARAMETER
S174
N
DATA FOR TRANSMISSION/RECEPTION EXISTS?
S175
Y
RFCA, SEND DEP_REQ TO TARGET DEVICE, AND RF-OFF
S176
RECEIVE DEP_RES SENT FROM TARGET DEVICE THAT RECEIVES DEP_REQ
S177
COMMUNICATION PARTNER IS CHANGED?
S178
N
Y
RFCA, SEND DSL_REQ OR RLS_REQ TO TARGET DEVICE, AND RF-OFF
S179
RECEIVE DSL_RES OR RLS_RES SENT FROM TARGET DEVICE THAT RECEIVES DSL_REQ OR RLS_REQ
S180
4
N
ALL DEVICES THAT RECOGNIZE NFCIDS ARE COMPLETELY RELEASED?
S181
Y
END

FIG. 23

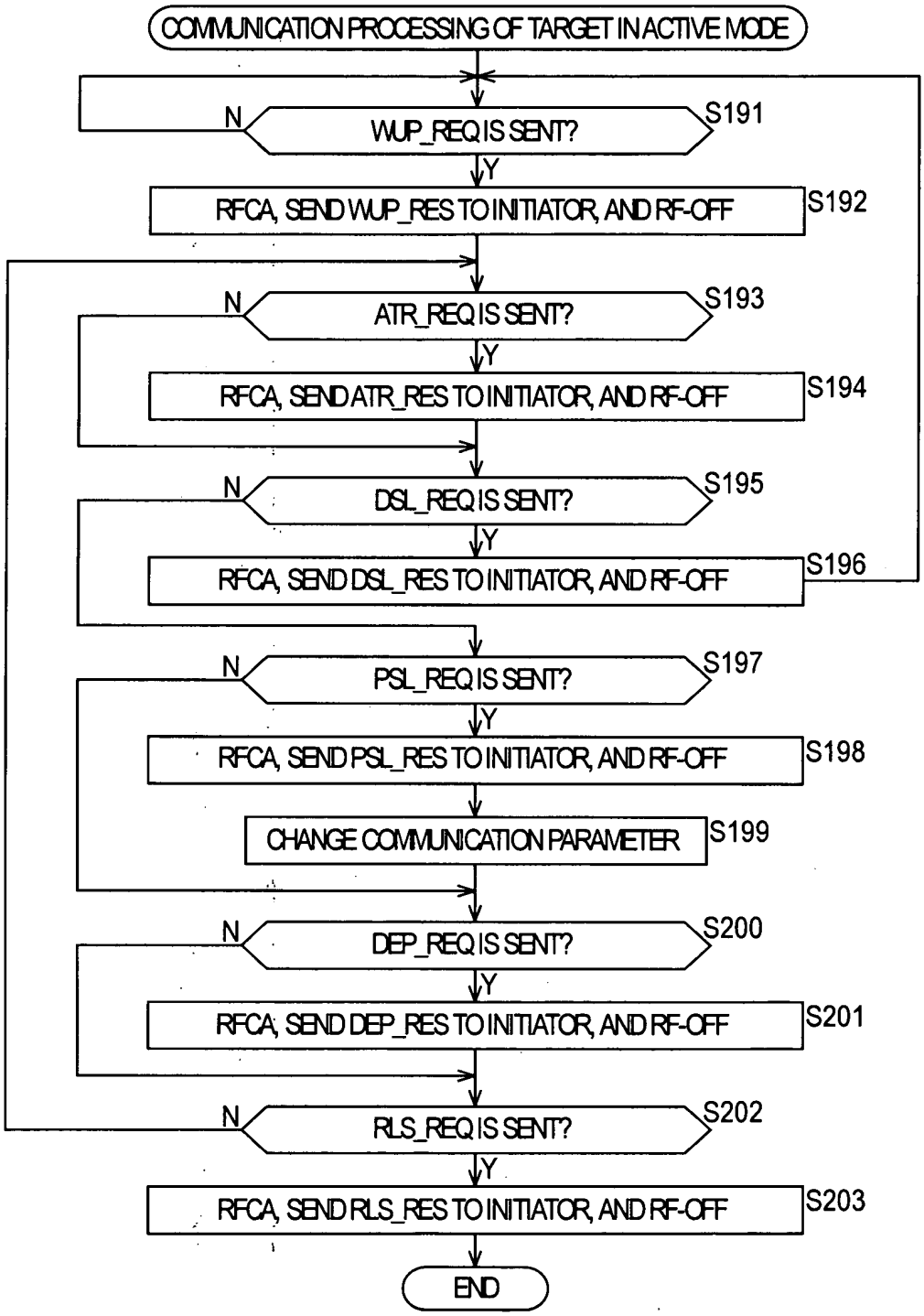

COMMUNICATION PROCESSING OF TARGET IN ACTIVE MODE
N
WUP_REQ IS SENT?
S191
Y
RFCA, SEND WUP_RES TO INITIATOR, AND RF-OFF
S192
N
ATR_REQ IS SENT?
S193
Y
RFCA, SEND ATR_RES TO INITIATOR, AND RF-OFF
S194
N
DSL_REQ IS SENT?
S195
Y
RFCA, SEND DSL_RES TO INITIATOR, AND RF-OFF
S196
N
PSL_REQ IS SENT?
S197
Y
RFCA, SEND PSL_RES TO INITIATOR, AND RF-OFF
S198
CHANGE COMMUNICATION PARAMETER
S199
N
DEP_REQ IS SENT?
S200
Y
RFCA, SEND DEP_RES TO INITIATOR, AND RF-OFF
S201
N
RLS_REQ IS SENT?
S202
Y
RFCA, SEND RLS_RES TO INITIATOR, AND RF-OFF
S203
END

FIG. 24

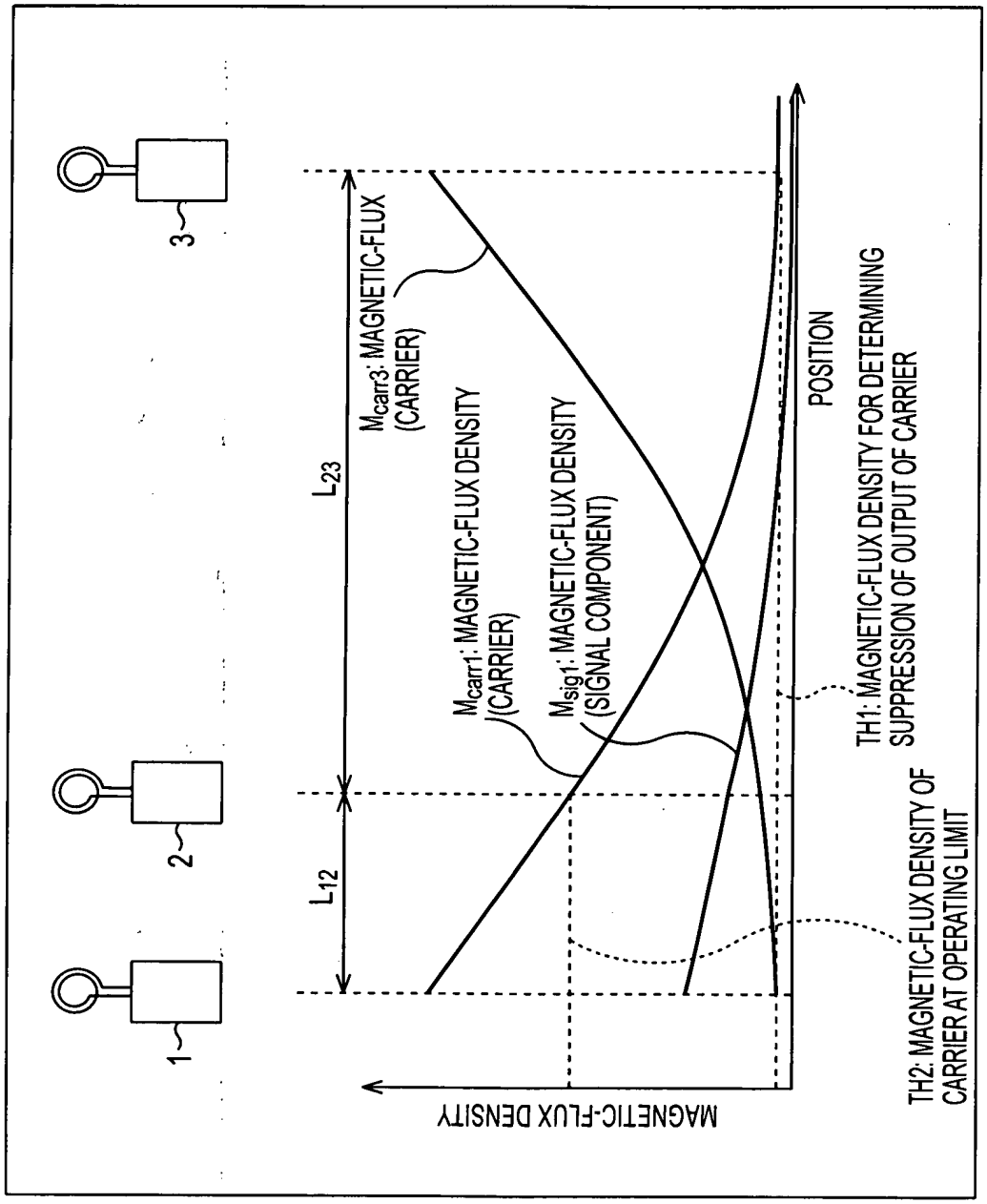

1
2
3
L_{12}
L_{23}
M_{carr3}: MAGNETIC-FLUX (CARRIER)
M_{carr1}: MAGNETIC-FLUX DENSITY (CARRIER)
M_{sig1}: MAGNETIC-FLUX DENSITY (SIGNAL COMPONENT)
POSITION
MAGNETIC-FLUX DENSITY
TH1: MAGNETIC-FLUX DENSITY FOR DETERMINING SUPPRESSION OF OUTPUT OF CARRIER
TH2: MAGNETIC-FLUX DENSITY OF CARRIER AT OPERATING LIMIT

FIG. 25

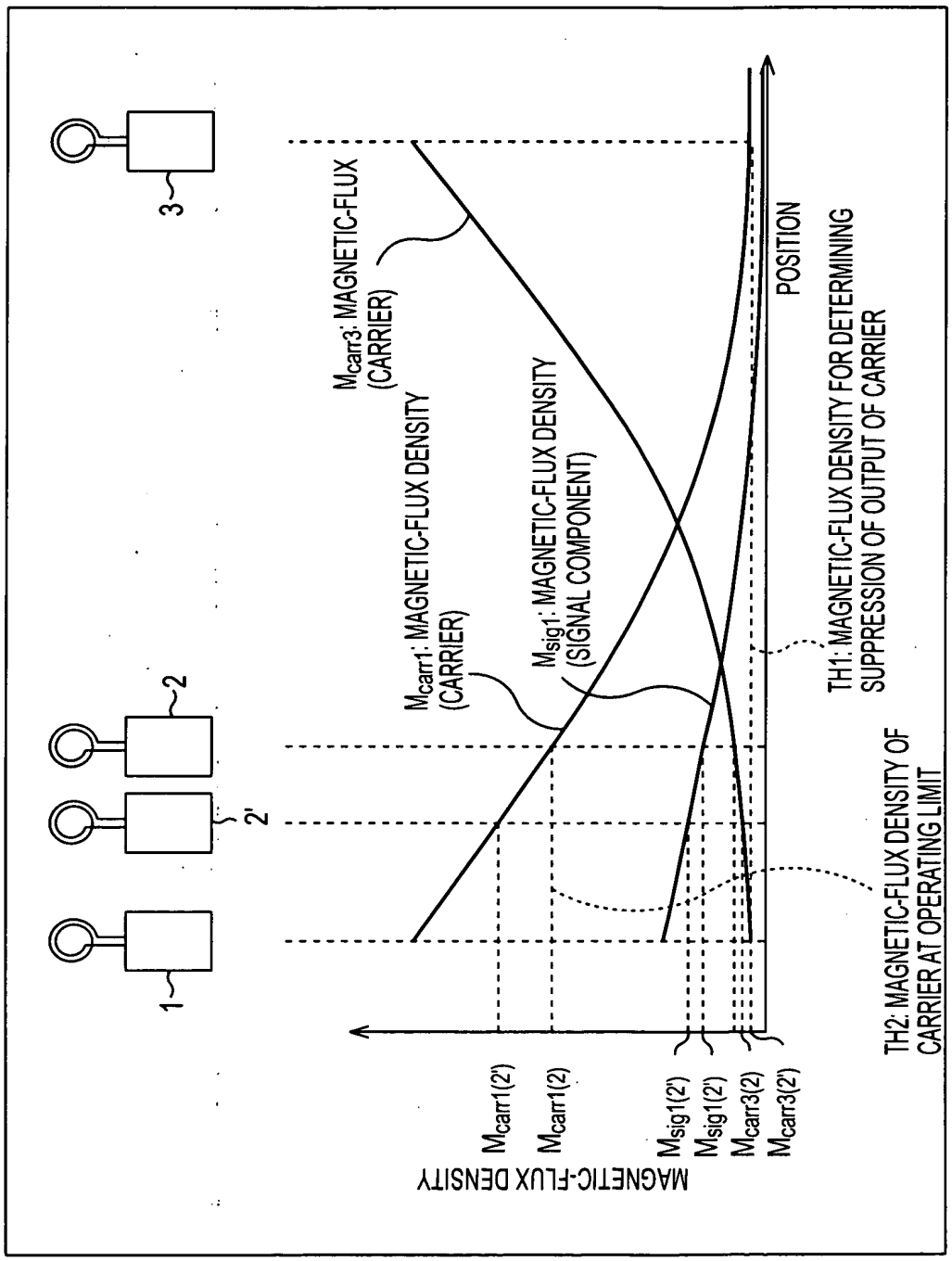

1
2
2'
3
M_{carr3}: MAGNETIC-FLUX (CARRIER)
M_{carr1}: MAGNETIC-FLUX DENSITY (CARRIER)
M_{sig1}: MAGNETIC-FLUX DENSITY (SIGNAL COMPONENT)
POSITION
TH1: MAGNETIC-FLUX DENSITY FOR DETERMINING SUPPRESSION OF OUTPUT OF CARRIER
TH2: MAGNETIC-FLUX DENSITY OF CARRIER AT OPERATING LIMIT
MAGNETIC-FLUX DENSITY
$M_{carr1(2')}$
$M_{carr1(2)}$
$M_{sig1(2')}$
$M_{sig1(2')}$
$M_{carr3(2)}$
$M_{carr3(2')}$

FIG. 26

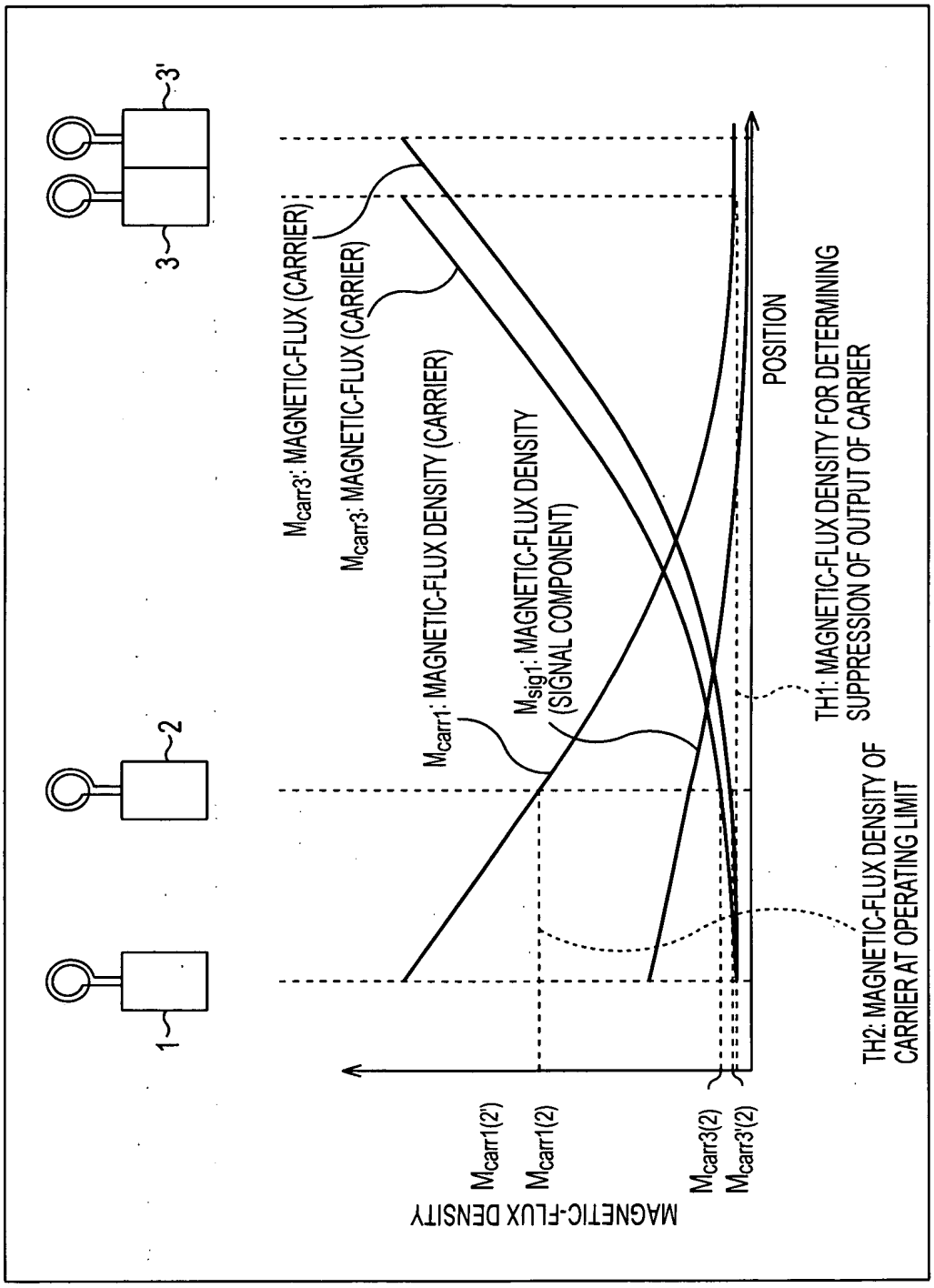

1
2
3
3'
$M_{carr3'}$: MAGNETIC-FLUX (CARRIER)
M_{carr3}: MAGNETIC-FLUX (CARRIER)
M_{carr1}: MAGNETIC-FLUX DENSITY (CARRIER)
M_{sig1}: MAGNETIC-FLUX DENSITY (SIGNAL COMPONENT)
POSITION
TH1: MAGNETIC-FLUX DENSITY FOR DETERMINING SUPPRESSION OF OUTPUT OF CARRIER
TH2: MAGNETIC-FLUX DENSITY OF CARRIER AT OPERATING LIMIT
MAGNETIC-FLUX DENSITY
$M_{carr1(2')}$
$M_{carr1(2)}$
$M_{carr3(2)}$
$M_{carr3'(2)}$

FIG. 27

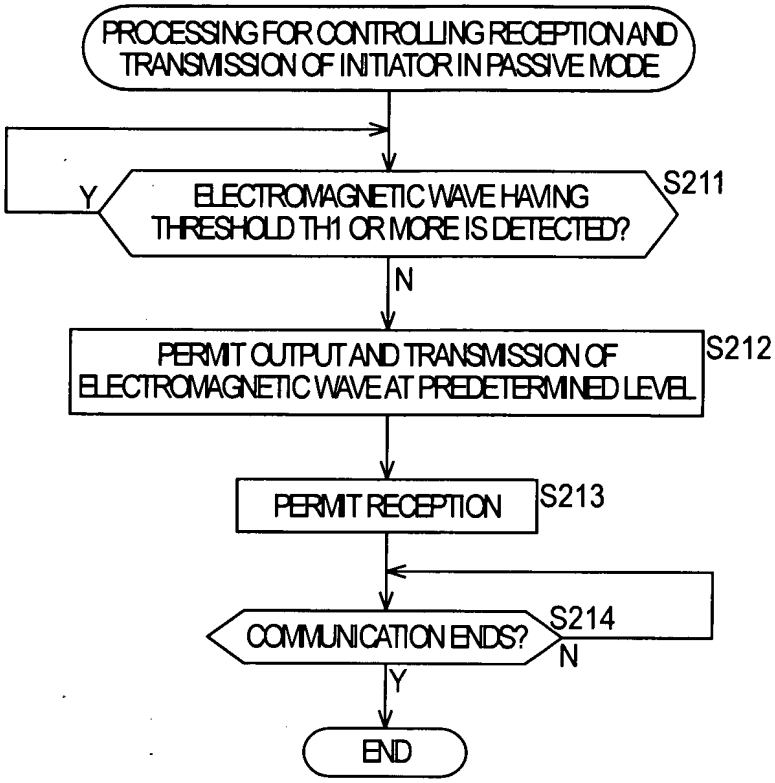

PROCESSING FOR CONTROLLING RECEPTION AND TRANSMISSION OF INITIATOR IN PASSIVE MODE
ELECTROMAGNETIC WAVE HAVING THRESHOLD TH1 OR MORE IS DETECTED?
S211
Y
N
PERMIT OUTPUT AND TRANSMISSION OF ELECTROMAGNETIC WAVE AT PREDETERMINED LEVEL
S212
PERMIT RECEPTION
S213
COMMUNICATION ENDS?
S214
N
Y
END

FIG. 28

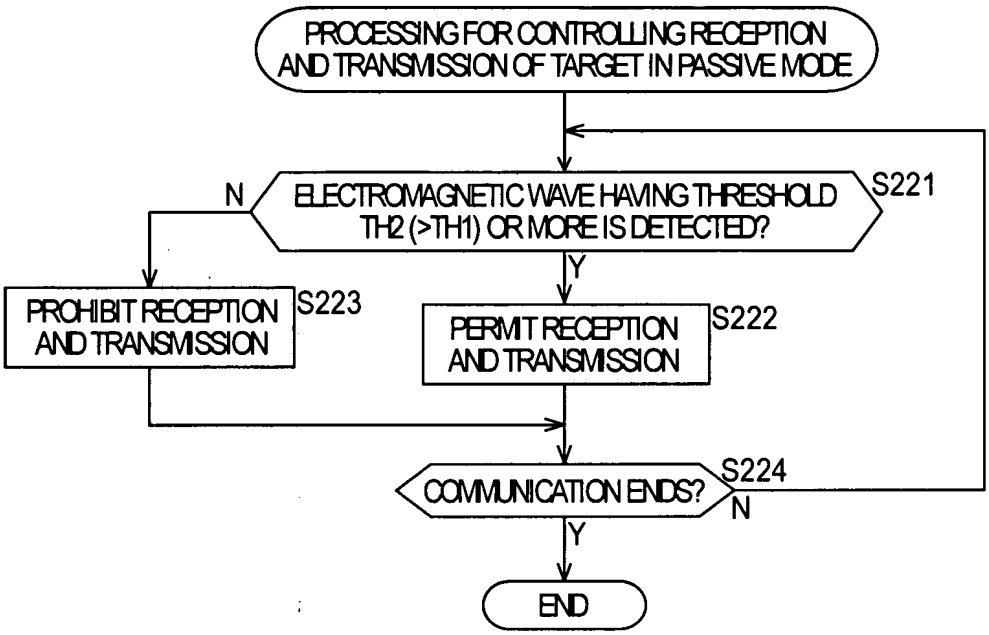

PROCESSING FOR CONTROLLING RECEPTION AND TRANSMISSION OF TARGET IN PASSIVE MODE
ELECTROMAGNETIC WAVE HAVING THRESHOLD TH2 (>TH1) OR MORE IS DETECTED?
S221
N
Y
PROHIBIT RECEPTION AND TRANSMISSION
S223
PERMIT RECEPTION AND TRANSMISSION
S222
COMMUNICATION ENDS?
S224
N
Y
END

FIG. 29

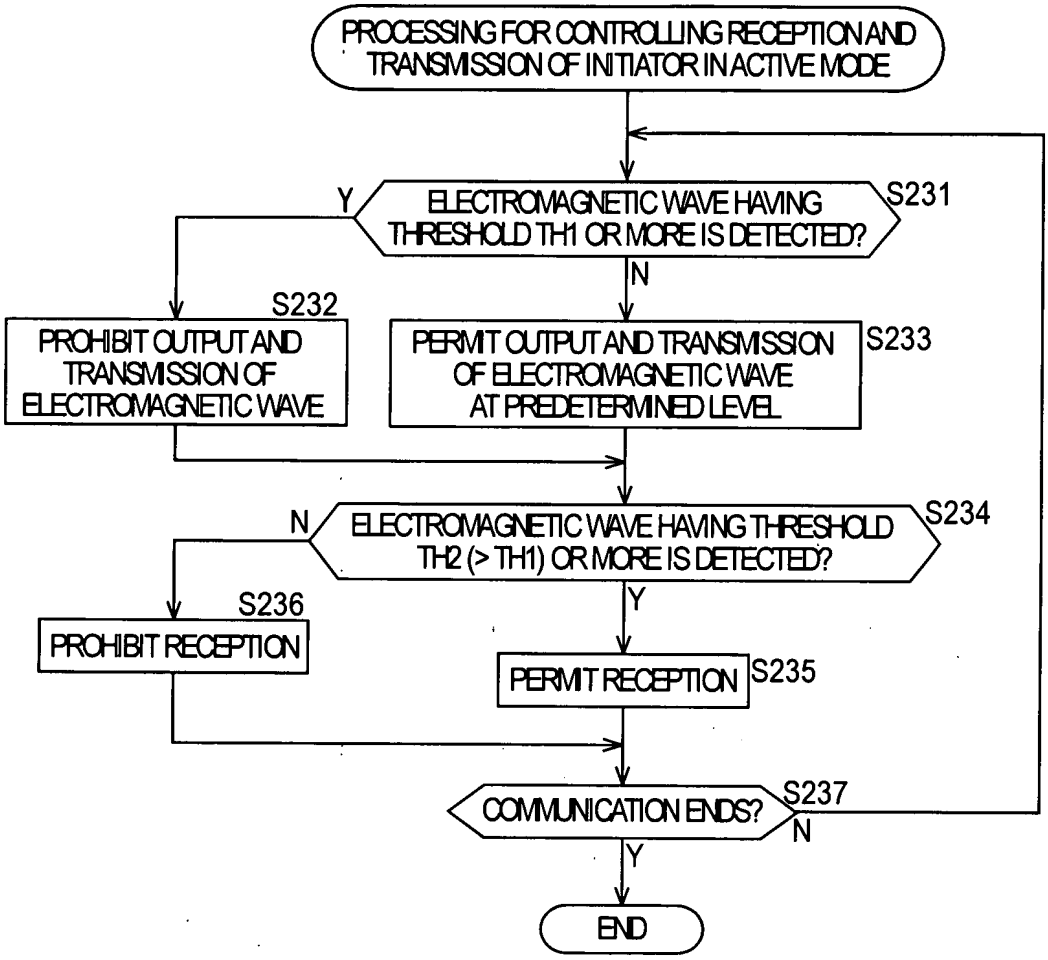
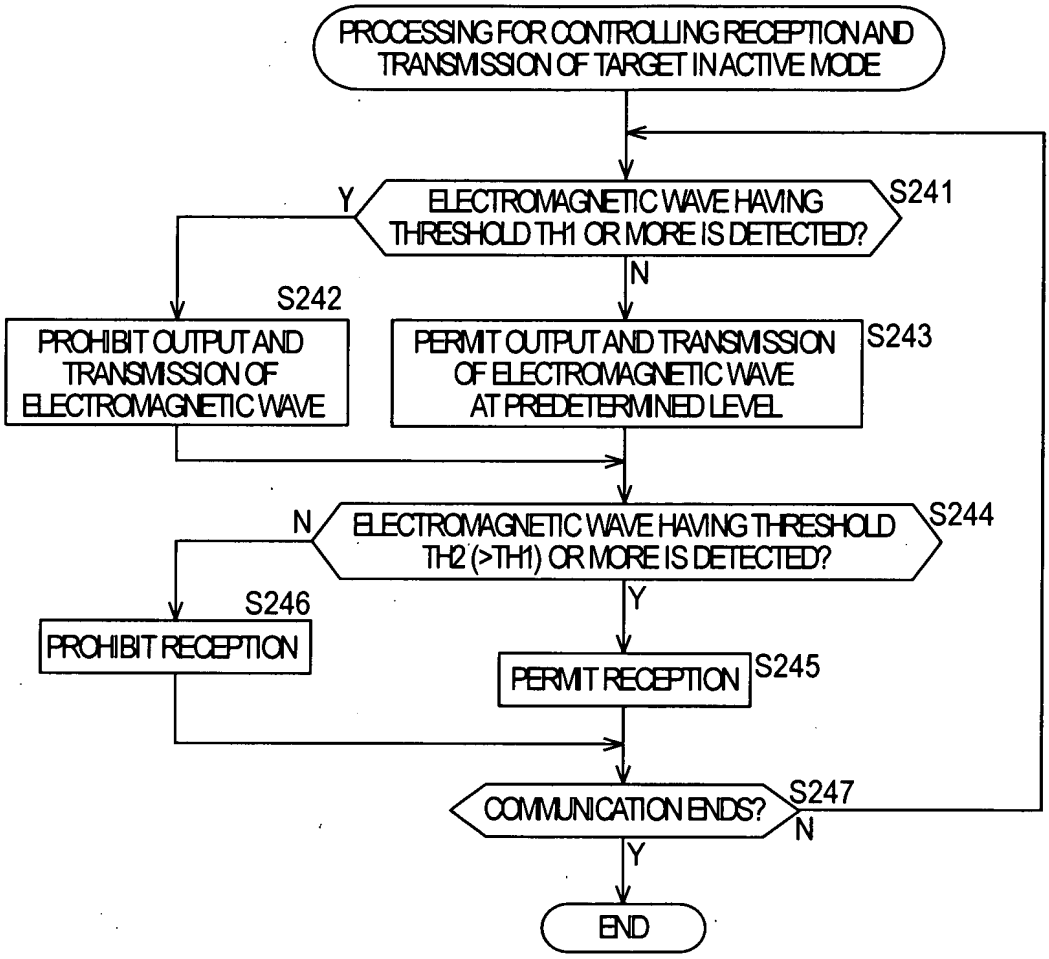

PROCESSING FOR CONTROLLING RECEPTION AND TRANSMISSION OF INITIATOR IN ACTIVE MODE
ELECTROMAGNETIC WAVE HAVING THRESHOLD TH1 OR MORE IS DETECTED?
S231
Y
N
PROHIBIT OUTPUT AND TRANSMISSION OF ELECTROMAGNETIC WAVE
S232
PERMIT OUTPUT AND TRANSMISSION OF ELECTROMAGNETIC WAVE AT PREDETERMINED LEVEL
S233
ELECTROMAGNETIC WAVE HAVING THRESHOLD TH2 (> TH1) OR MORE IS DETECTED?
S234
N
Y
PROHIBIT RECEPTION
S236
PERMIT RECEPTION
S235
COMMUNICATION ENDS?
S237
N
Y
END

FIG. 30


PROCESSING FOR CONTROLLING RECEPTION AND TRANSMISSION OF TARGET IN ACTIVE MODE
ELECTROMAGNETIC WAVE HAVING THRESHOLD TH1 OR MORE IS DETECTED?
S241
Y
N
PROHIBIT OUTPUT AND TRANSMISSION OF ELECTROMAGNETIC WAVE
S242
PERMIT OUTPUT AND TRANSMISSION OF ELECTROMAGNETIC WAVE AT PREDETERMINED LEVEL
S243
ELECTROMAGNETIC WAVE HAVING THRESHOLD TH2 (>TH1) OR MORE IS DETECTED?
S244
N
Y
PROHIBIT RECEPTION
S246
PERMIT RECEPTION
S245
COMMUNICATION ENDS?
S247
N
Y
END